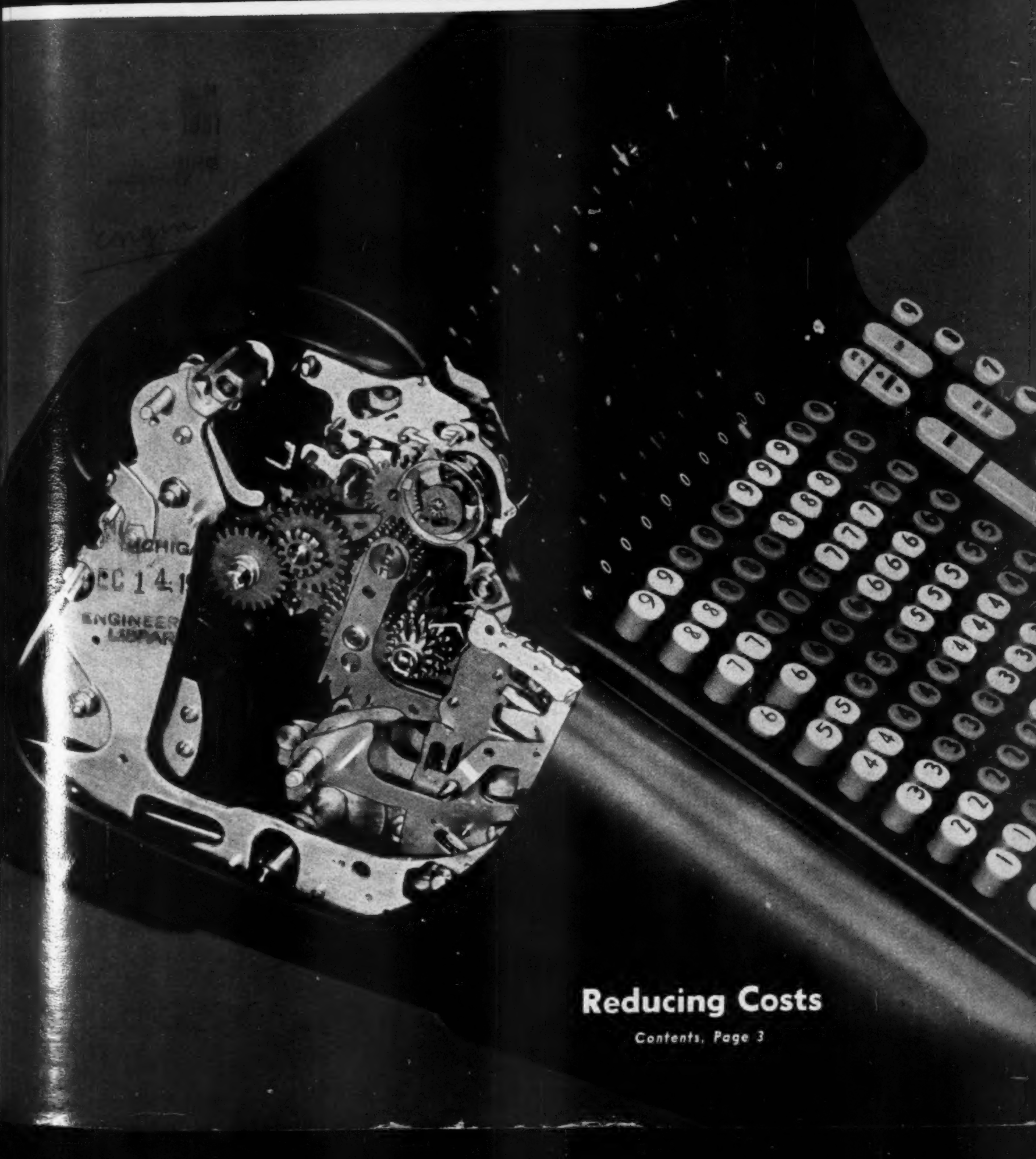
MACHINE DESIGN

December 1951



Reducing Costs

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MACHINE DESIGN

THE PROFESSIONAL JOURNAL FOR ENGINEERS AND DESIGNERS

Vol. 23—No. 12 **December 1951**

DESIGN FOR PRODUCTION • STYLING • MATERIALS SPECIFICATION • DESIGN ANALYSIS • MACHINE COMPONENTS • ENGINEERING MANAGEMENT

Over the Board

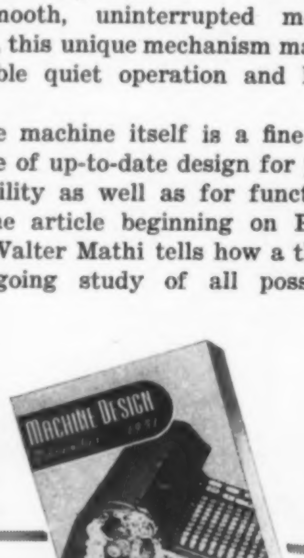
Mathematics

The other night, across the dinner table, we heard an observation that left quite an impression. One of the diners, who is a mathematician with an important machinery manufacturer, was asked what his job consisted of—where such a company as his could use a mathematician. The answer was illuminating: "If the mechanical and electrical engineers ever remembered what they learned in school, I would be out of a job." Not likely to inflate the ego of the engineer, the remark is a wry commentary on a short-coming shared by too many designers. So intent on being "practical" many of us have lost sight of one of the most powerful tools of our trade.

This Month's Cover

Exposed in the cutaway Kodachrome view on this month's cover is the proportional gear actuator of the Marchant Figuremaster. Transmitting values to the dials in a smooth, uninterrupted movement, this unique mechanism makes possible quiet operation and long life.

The machine itself is a fine example of up-to-date design for producibility as well as for function. In the article beginning on Page 110 Walter Mathi tells how a thoroughgoing study of all possible production processes resulted in a simpler design, less expensive to produce. It goes without saying that liberal doses of imagination and plain horse sense are essential ingredients in this sort of activity.



Intermittent Mechanisms

From pages 134 to 148 in this issue you'll find an unusually long article. These 15 pages represent, at one and the same time, the most comprehensive and yet concise treatment of Geneva mechanisms we ever remember seeing. But that's not all. In succeeding issues we shall present equally comprehensive articles on other intermittent mechanisms, including such types as star wheels and gears for intersecting and crossed shafts.

This brings up a point. When we realize that a lengthy series such as this (it may total close to 50 pages) would be of great interest and value to design engineers, the question arises, how should it be presented? Three or four lengthy articles? Eight or ten normal length articles? This time we chose the former course in order to give you complete coverage of at least one phase in each article and have the whole series in your hands within a reasonable time.

How Long on the Job?

A recent survey covering fifty plants in one area has brought out some interesting figures on how long design engineers have been working at their present jobs. Here they are for what they're worth: 33 per cent have held their present jobs for less than ten years, 12 per cent for 6 to 10 years, 27 per cent for 11 to 15 years, 9 per cent for 16 to 20 years, and 12 per cent for over 20 years. Only 7 per cent failed to answer the questionnaire. It is perhaps significant that nearly 50 per cent have held their present jobs for more than ten years, an indication of stability and perhaps a clue to the number of engineers who find themselves on or approaching the salary plateau discussed in an editorial earlier this year.

Engineering Data Sheets

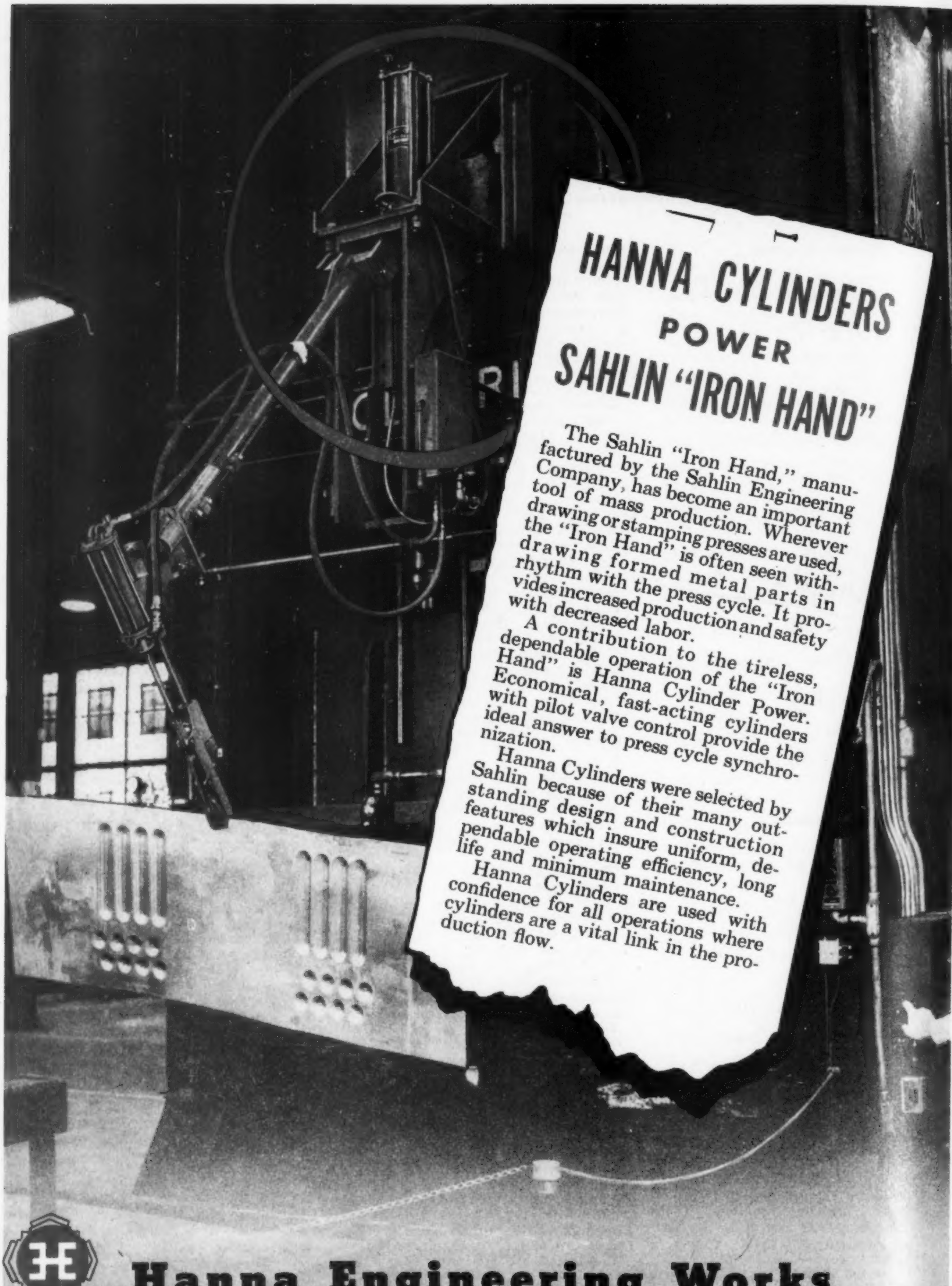
Almost every designer has his personal file of special aids — short cuts or simplifications of routine calculations, and other information of a handbook sort. From the number of your requests, we know that MACHINE DESIGN's Data Sheets are helping this cause. For good measure we're presenting two Data Sheets this month on different subjects, Pages 163 and 165.

Our aim is to publish useful design data or simplified, time-saving procedures that are not available in standard reference sources. Subjects for this regular feature are innumerable. However, some of you may have created special aids for your own work that you feel would be helpful to others. If so, don't wait to be invited—let us hear about them. Or, if you believe a particular Data Sheet, as yet nowhere available, would be of practical help on some aspect of design, tell us about it. Perhaps we can develop the idea.

ITEMIZED INDEX

Classified for convenience when studying specific design problems

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries generally.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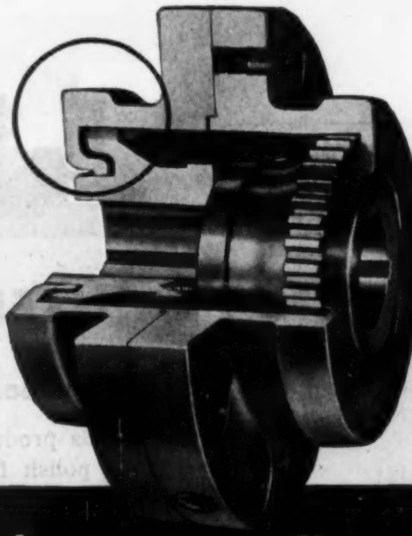

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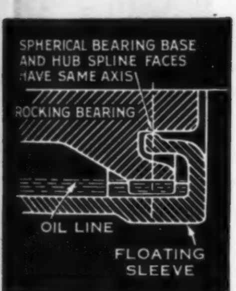

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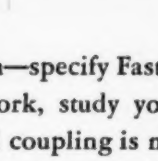

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MACHINE DESIGN
A PENTON PUBLICATION

TOPICS

...IN ENGINEERING AND RESEARCH

Soft Lenses Polished with Barber-Shop Technique

Soap suds produced by a barber-shop lather dispenser are the only satisfactory polish for soft lenses of the kind which transmit invisible light and heat rays. Conventional grinding techniques, using even the finest of abrasive powders, leave heavy scratches on these heavy-metal halide crystals. But soap suds containing garnet or aluminum-oxide powders do a fine job, according to the Naval Research Laboratory. Not only does the lather float away particles which might scratch the crystals, but also seems to have a polishing effect of its own.

Fluorochemicals To Do "Impossible" Jobs

Having high resistance to heat, acid formation and corrosion, fluorochemicals are expected by R. P. Carlton, president of Minnesota Mining & Manufacturing Co., to handle many tough or previously impossible jobs. One of the major obstacles in developing new uses has been the difficulty of manufacturing fluorochemicals—since free fluorine, which is extremely dangerous, must be handled at some stage in production. A new semicommercial process overcomes this difficulty by producing fluorocarbons from hydrogen fluoride.

Pilot Trainer Simulates Two Planes in Flight

Without even leaving the ground, F-86D Sabre jet pilots will now be able to bag an enemy plane approaching at the speed of sound. Containing over 100,000 parts, 1152 electronic tubes and 60 miles of wiring, a new trainer built by the Engineering and Research Corp. is the first to simulate two planes in flight. A battery of analogue computers automatically changes the cockpit instrument readings to conform to simulated flight conditions, and if the pilot makes a mistake its effect will automatically carry through, even to the extent of "crashing" the plane.

Canned Foods Inspected with X-Rays

Able to inspect 576,000 cans per day for food level, a new General Electric detector sends a tiny beam of X-rays through the cans as they pass on a conveyor belt. A crystal detector measures variations in X-ray absorption caused by the level of food and either passes the can or removes it.

Nylon Improves Battle Helmets

If Army Quartermaster field tests work out, the WACs may not be the only ones to receive government-issue nylons. A new laminated-nylon helmet, worn under an aluminum shell, is reported to have greater resistance to missiles than present steel helmets. Body armor also being tested includes a suit of pressed-nylon fabric layers and a cotton jacket with front and back pockets containing laminated glass-fiber and plastic panels.

Graphical Differentiation . . . with a Mirror

A clever trick described by J. M. Ramrath of Allis-Chalmers for evaluating slope of nonlinear curves is the use of an upright steel straightedge

TOPICS

polished to a mirror finish. The mirror is placed approximately normal to the curve, then rotated until the mirror image appears to be a perfectly smooth continuation of the real curve. The straightedge then represents a line normal to the curve at the selected point; its perpendicular is the instantaneous slope. Ordinary glass mirrors, having their reflecting surfaces on the rear, cannot be used because of the parallax error introduced by the thickness of the glass.

Electric Current Generated by Atomic Battery

An atomic battery developed by the Ohmart Corp. represents the first practical method of converting radioactive energy direct to electrical energy. The cell, when subjected to gamma-ray radiation, produces enough current to run a small "gnat-power" motor, but its main use will be in instruments. Chief virtue is that a cell plus one vacuum tube can replace an instrument requiring twenty to thirty vacuum tubes.

...IN GOVERNMENT AND INDUSTRY

Materials Demand Near Peak

Demand for materials will probably hit its highest peak during the first quarter of 1952, according to Charles E. Wilson, Defense Mobilization Director. By the third quarter, currently expanding production facilities should begin to ease the situation. Crucial factor causing the first-quarter squeeze, especially in metals, is an unusually heavy demand by the military. A summary of the current materials situation is presented on Page 210 in this issue.

Defense Production Rate To Increase

Deliveries of military goods during the July-September quarter of 1951 are estimated at more than $5 billion. This total is one-third more than the preceding quarter, and more than four times last year's rate. Within a year, as industry emerges from its present tooling-up phase to full volume output, production is expected to double, reaching $10 to $11 billion per quarter. This rate of expansion should be attained without causing serious shortages of consumer goods, except those requiring critical metals.

Machine Tool Output Lags

Although output of machine tools has increased steadily during the past year, the backlog of orders increased even more. The most serious shortage will probably occur in late 1952 or early 1953, according to NPA, with production catching up with demand after that date. Lack of manpower and steel is responsible for most of the trouble. An unwillingness to overexpand production facilities, understandable in the light of the "boom-and-bust" experience of machine-tool builders after World War II, has contributed. To take up the slack, builders of less-essential machines have been urged by the government to convert partly to machine tools.

Component Shortages Grow

Already buried under stacks of orders, many parts suppliers are feeling the increased pressure of materials shortages. Manufacturers of plain bearings report that a critical shortage may develop unless they receive assistance in obtaining lead. Demand for valves and valve fittings is greater than present production, with manufacturers drawing on dwindling stocks of raw materials to turn out present orders. Timing device manufacturers are suffering from a secondary effect, that of holding skilled workmen in the face of low production caused by reduced materials allocations. And pump motor output, even though high, will be hard-pressed to keep up with the demand, especially in large sizes.

DECEMBER 1951

Possibilities Unlimited

WHEN a famous steamship company announced plans to build two transatlantic liners some years ago it was stated that they would be the smallest, slowest craft that could maintain a weekly schedule with only two ships. Known today as the two Queens, these ships turned out to be the largest, fastest passenger liners in the world. There is no paradox here. Detailed cost studies showed that the ships as designed actually are the smallest and slowest that will satisfactorily perform their particular task.

It can be said, too, that the best design of any machine or appliance is the simplest that will do the job, simplicity implying few parts of minimum complexity, as well as ease of manufacture, assembly and maintenance. If the machine happens to be a modern office calculator, or an automatic transmission, or an aircraft engine, the design may appear complex yet still be the simplest that will do the job. Simplicity is relative, like size and performance of a ship.

With an understanding of what simplicity means in a particular type of machine, how can the designer be sure of attaining the best practical level of simplicity? There is only one answer: By exploring all possible alternate designs. Then for each alternate the proposed materials and processes, and their probable effects on performance and cost, can be compared.

Time thus spent in analyzing alternate designs can pay off in a big way. In the example of the office calculator discussed in this month's lead article, cost savings as high as fifty per cent are being realized. The essential ingredient for success such as this is an insatiable curiosity on the part of the explorer and a refusal to leave any stones unturned.

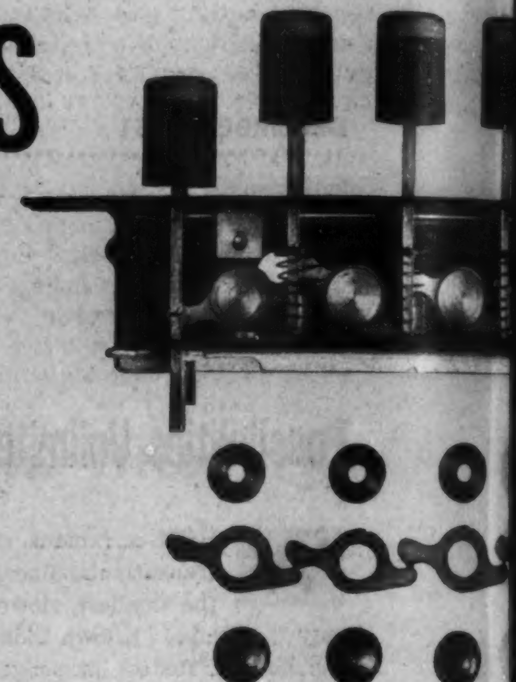
Possibilities are still unlimited in the field of engineering design. The major deterrent is the human tendency to employ only surefire, trusted design procedures. Such ultraconservatism may mean bypassing less obvious but potentially superior designs.

Need for rock-bottom simplicity and cost has never been greater. Added to the usual factor of competition is the increasingly urgent need for conservation—conservation of materials, of manpower, of tools. The key lies in the hands of the design engineer; no one else has a better perspective.

Colin Carmichael

EDITOR

REDUCING COSTS



. . . through design simplification

By Walter E. Mathi
Development Engineer
Marchant Calculating Machine Co.
Oakland, California

IN THE manufacture of competitive commodities, design for maximum simplicity and low-cost production is becoming more important than ever in view of rising labor, material and burden costs. This calls for more alert engineering to avoid designs which cannot be manufactured economically under present conditions. These circumstances make it imperative that new as well as existing designs be carefully examined from the production point of view. Nothing should be overlooked that could possibly contribute towards reduction in manufacturing costs if practical and if no sacrifice is made in quality.

Nearly all designs may be simplified without affecting their functions. Sometimes these simplifications are of only a minor nature and concern unit parts. In other instances more extensive reductions in cost may be effected by a complete redesign of an operating mechanism. This applies particularly to designs produced on limited time schedules. Engineers are often required to finish their respective designs in the shortest possible time and, while providing for safe and efficient performance to the best of their ability, they may neglect to consider those points which facilitate mass production.

The most obvious economies are sometimes purposely avoided in favor of more costly conventional designs since limited time does not always permit the testing of untried ideas. This is often true of the mechanisms in business machines which use a relatively large number of parts. Substantial savings can often be made by redesigning units and individual parts so as to better adapt them to mass-production techniques utilizing punch presses and automatic screw machines to a maximum. Such equipment requires less machine time and labor cost than milling machines, grinders, lathes, etc.

Manufacturing of business equipment requires a large investment in tooling and machinery which must be operated and maintained by an extensive staff. Each flat part usually requires several different tools including blank, pierce, form, shave, trim, and reset dies. In addition, many special gages and adjustment fixtures are needed for inspection and assembly. Since the product may contain several hundred or even several thousand different flat parts each of which requires a number of tools to perform the steps required in its fabrication, it is apparent that a considerable number of operations go into the manufacture of a calculator or a comparable machine.

To minimize the number of operations requires alertness on the part of engineering and manufacturing staffs. The manufacturing divisions can help reduce the number of these operations by improving their various production processes while engineering can effectively do so by simplifying design in three ways:

1. Reduce the number of parts without detriment to the final product

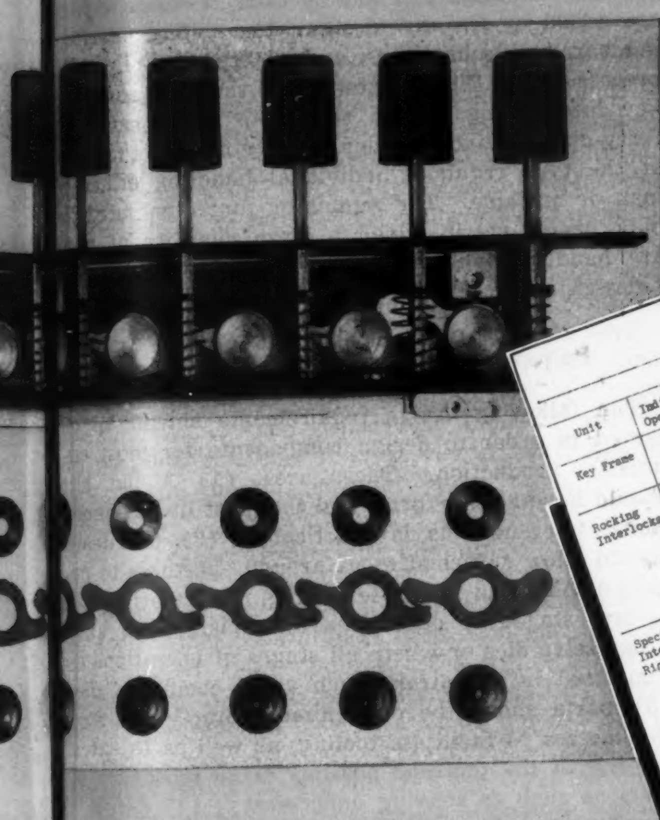
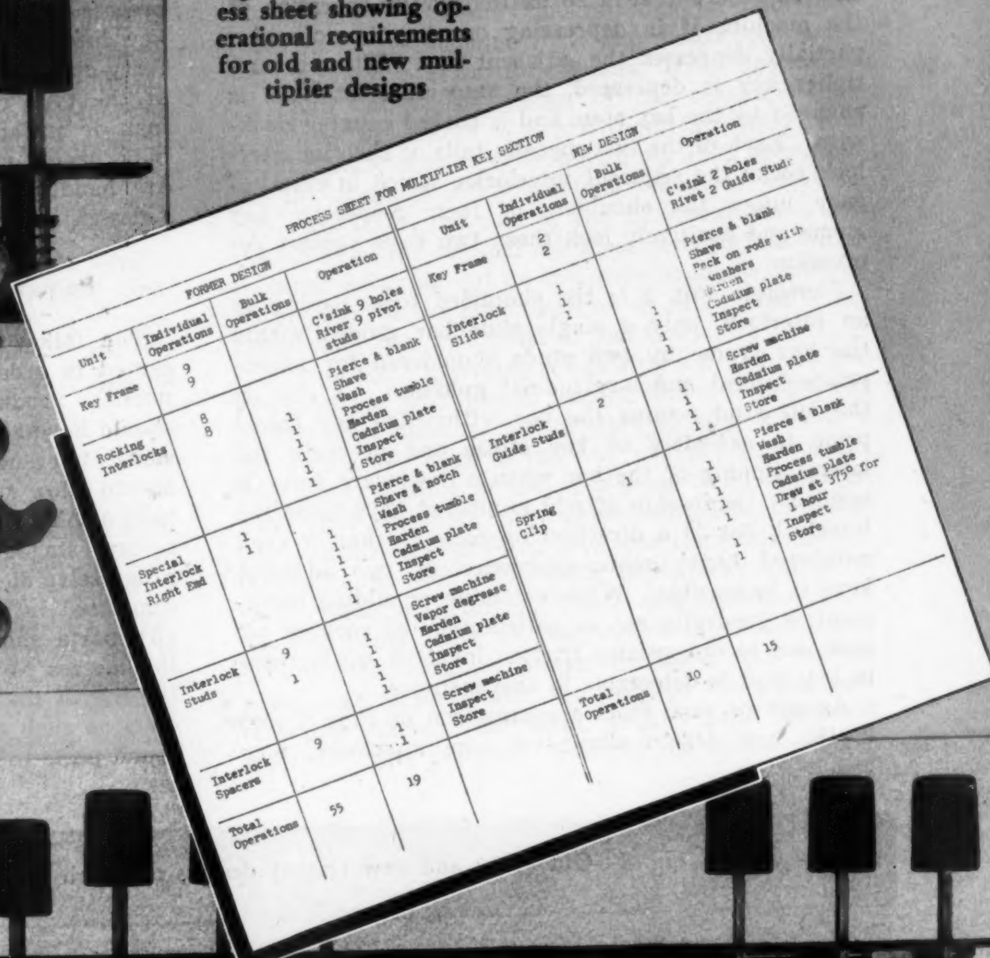


Fig. 1—Above—Original design of Marchant multiplier key section and separate parts for interlocking

Fig. 3—Below—Process sheet showing operational requirements for old and new multiplier designs



PROCESS SHEET FOR MULTIPLIER KEY SECTION

FORMER DESIGN				NEW DESIGN			
Unit	Individual Operations	Bulk Operations	Operation	Unit	Individual Operations	Bulk Operations	Operation
Key Frame	9 9		C'sink 9 holes River 9 pivot studs	Key Frame	2 2		C'sink 2 holes Rivet 2 Guide Studs
Rocking Interlocks	8 8	1 1 1 1 1 1	Pierce & blank Shave Wash Process tumble Harden Cadmium plate Inspect Store	Interlock Slide	1 1 1	1 1 1 1	Pierce & blank Shave Pack on rods with washers [illegible] Cadmium plate Inspect Store
Special Interlock Right End	1 1	1 1 1 1 1 1	Pierce & blank Shave & notch Wash Process tumble Harden Cadmium plate Inspect Store	Interlock Guide Studs	2	1 1 1 1	Screw machine Harden Cadmium plate Inspect Store
Interlock Studs	9 1	1 1 1 1 1	Screw machine Vapor degrease Harden Cadmium plate Inspect Store	Spring Clip	1	1 1 1 1 1 1 1	Pierce & blank Wash Harden Process tumble Cadmium plate Draw at 375° for 1 hour Inspect Store
Interlock Spacers	9	1 ..1	Screw machine Inspect Store	Total Operations	10	15	
Total Operations	55	19					

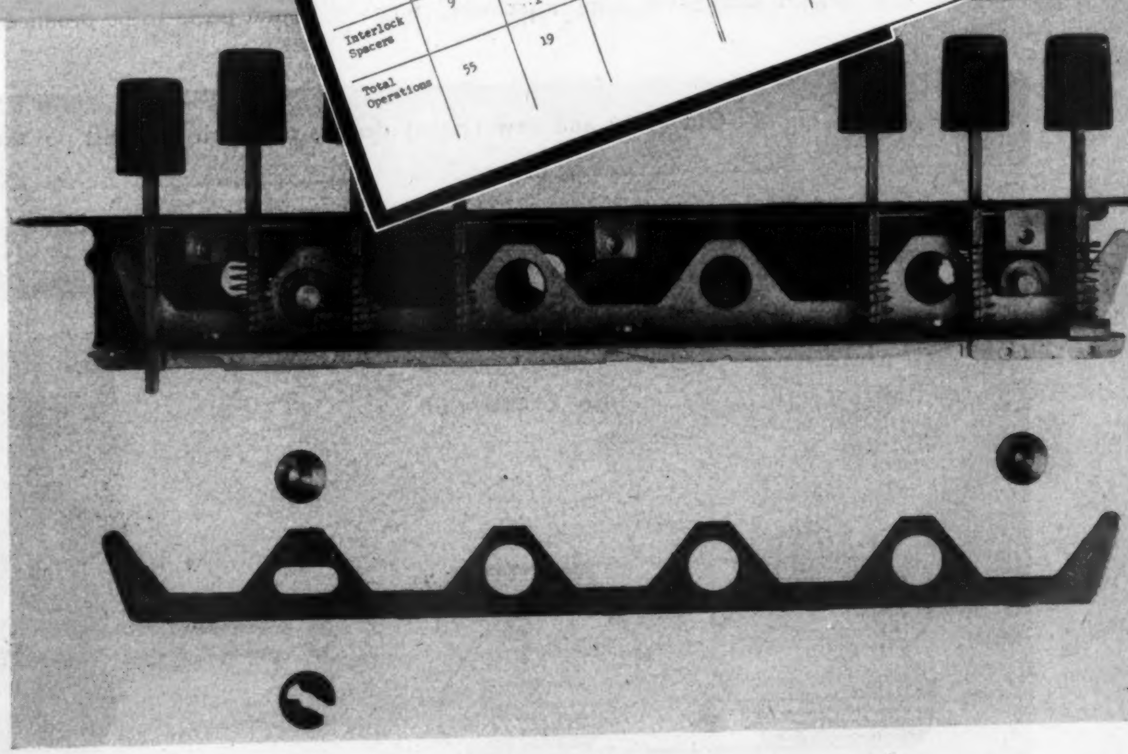


Fig. 2—Right—Redesigned multiplier key section showing four simple parts employed to replace those of *Fig.* 1

2. Redesign parts to reduce the number of shop operations
3. Redesign parts to reduce machine time and material required without necessarily reducing the number of shop operations.

Reducing Number of Parts: Any redesign having simplification as a purpose must meet certain requirements in order to be economically sound. New tooling should pay for itself in a comparatively short time—from six months to a year is the generally acceptable standard—and new parts should be as interchangeable as possible in models already in the field. A typical illustration of the first type of simplification by nonfunctional redesign is the multiplier key section used in a Marchant calculating machine shown prior to redesign in *Fig.* 1 and after redesign

in *Fig.* 2. The original multiplier key section, *Fig.* 1 is equipped with nine interlocks pivoted to the key section frame by studs riveted under flush. These interlocks prevent inadvertent simultaneous depression of adjacent keys so as to prevent operation of the machine if in depressing one key the operator partially depresses the adjacent key. When a multiplier key is depressed, the associated interlock is engaged by the key stem and is rocked counter clockwise. Each of the two opposite tails of such an interlock rocks the adjacent interlocks, which in turn engage under the shoulders of their respective key stems and positively lock these two keys against depression.

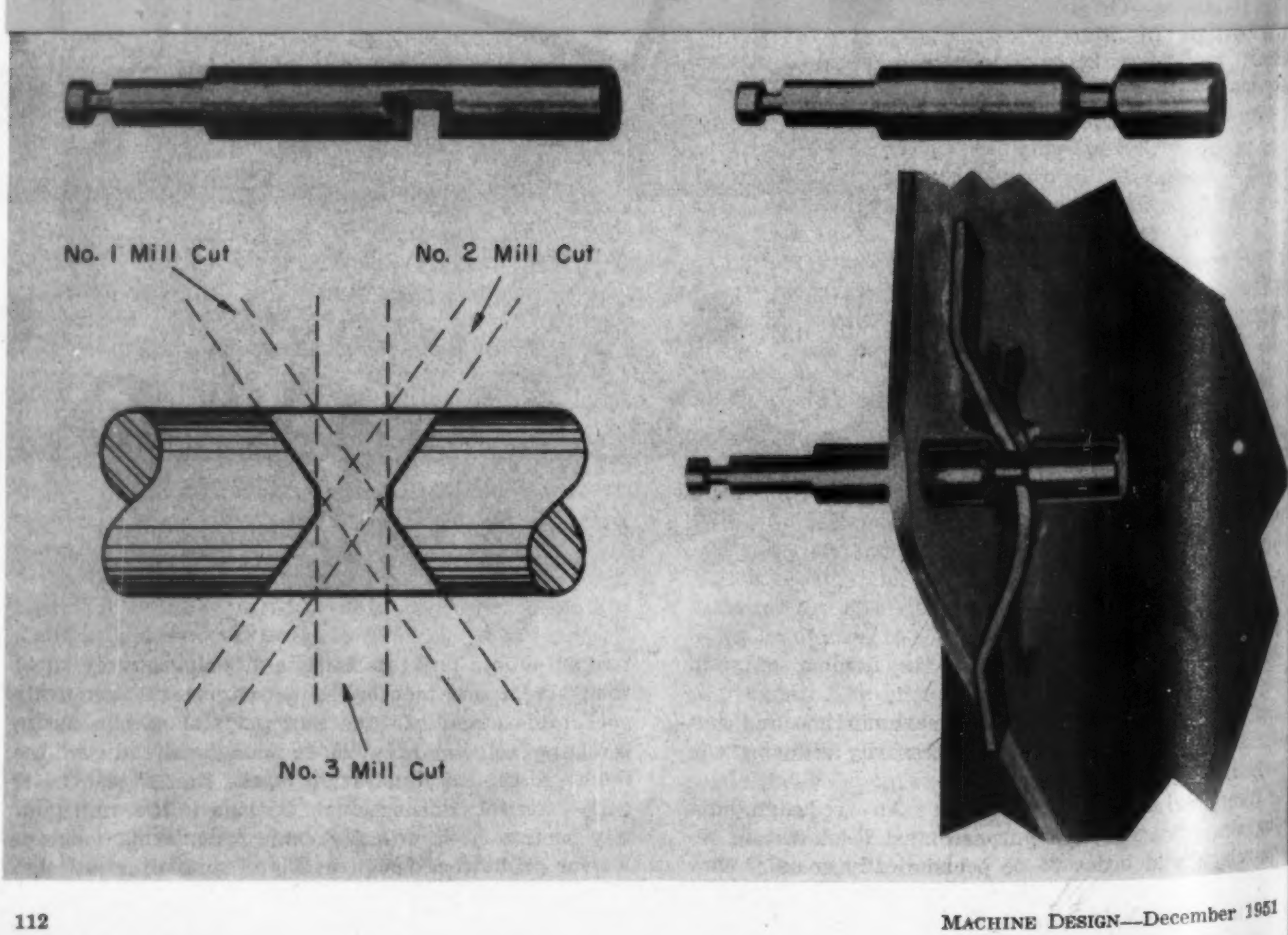
Shown in *Fig.* 2 is the simplified form having as an interlock, only a single slide bar guided within the key frame by two studs shouldered for appropriate lateral and longitudinal guidance. A clip on the left stud retains the bar within the key frame prior to assembly of key stems and prevents the lateral tipping of the bar when a downward force is applied. Depression of odd numbered keys cams the interlock bar in a direction opposite to that of even numbered keys; hence depression of two adjacent keys is impossible. While camming or sliding movement is generally not as satisfactory as rocking action, due to the greater friction involved, no increase in key load is detectable in this instance.

As can be seen from a comparison of *Figs.* 1 and 2, the new design eliminates nine interlocks, nine spacers, and nine studs, or a total of 27 parts from the original multiplier key section. Four new parts are added by the new design: the sliding interlocking bar, two guide studs, and one spacing clip. The process sheet, *Fig.* 3, shows that the new multiplier key interlocking system results in a net saving of forty-nine shop operations. Forty-five of these are of the type requiring individual handling either by man or machine. The remaining four eliminated are bulk operations in which a large quantity of parts are handled simultaneously. Simplification through redesign thus reduces cost by more than 50 per cent.

Requirements For Economical Design

The following design requirements should be observed in order to design components for most economical production. These are: (1) A flat part should have as few forms and the most liberal dimensional tolerances as is practicable; (2) the design should allow sufficient stock around apertures to prevent dishing and facilitate tooling, particularly where several stages of operations take place such as in progressive dies or where all stages of operations are completed in one stroke such as in compound dies; (3) parts should be of minimum practicable stock thicknesses to facilitate tooling, as well as to extend the life of the tool and possibly make secondary operations such as shaving unnecessary; (4) design of round parts to be produced on screw machines should

Fig. 4—Old (left) and new (right) designs of clutch key shift pin for calculator



preferably be such that all screw machine operations can be completed in one setup. Secondary operations are costly and sometimes result in less accurate parts.

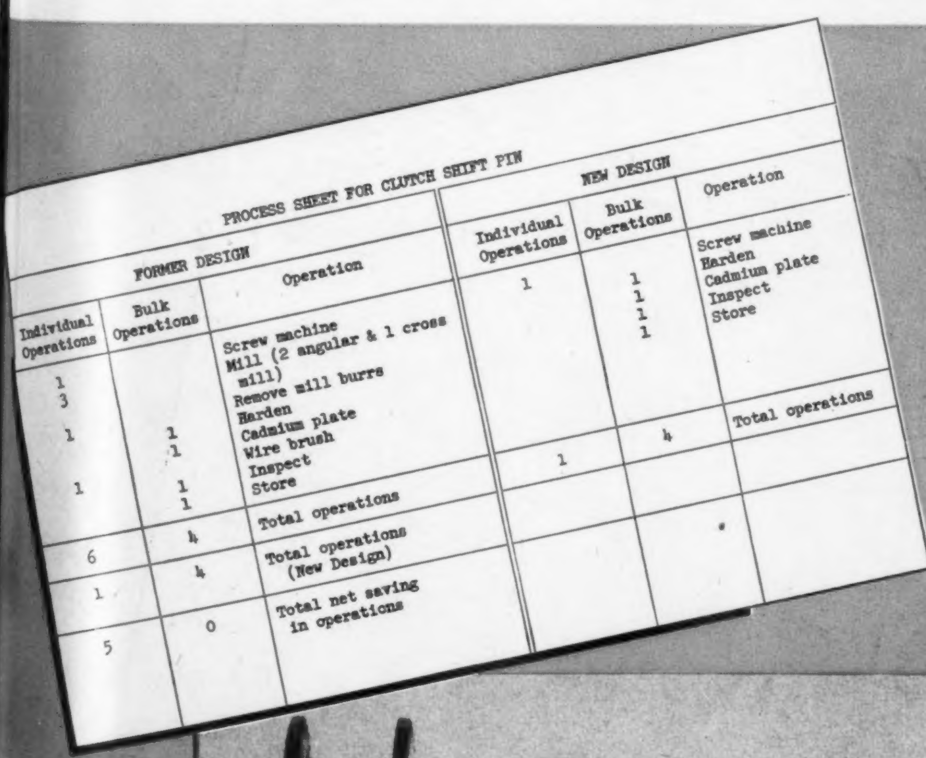
Reducing Number of Operations Per Part: The clutch key shift pin shown in *Fig.* 4 is an example of redesign for lower cost production through reduced shop operations and machine time. This shift pin sets the counter dial drive in the Marchant calculator to positive or negative driving direction depending on the type of calculation to be made. The actual shifting of this pin is accomplished by a lateral camming lever which is shown in engagement with the annular groove provided in the new shift pin design. This camming lever is shown held in a middle position in which the counter dials are driven in a negative direction. When adjusted to either of its two end positions this cam lever serves to locate the pin for a positive direction drive.

Slow Operations Eliminated

The original pin was equipped with a milled camming slot which, as will be noticed from the fragmentary enlarged view, requires three separate milling operations. The new construction eliminates these entirely and replaces them by a simple annular groove cut on a screw machine. The simplified design of this shift pin is ideally adapted for screw machine production because it requires no secondary machining operations. Savings in labor and machine time amount to 80 per cent of original cost, as may be seen by comparing the old and new process sheets for this part, *Fig.* 5.

Reducing Time Per Operation: The third type of simplification concerns the redesign of individual parts to reduce machine time, man hours, and material without necessarily reducing shop operations. The new three-piece design of the reverse double idler gear illustrated in *Fig.* 6 requires a total of 25 shop operations as compared with six shop operations for the original screw machine one-piece construction. However, the cost of the 25 operations is less than that of the original one-piece construction which required roughing out on the screw machine followed by hobbing of the gear teeth on an arbor able to accommodate only two units at one time.

A three-piece assembly comprising a keyed hub and two separate gear blanks was at first attempted but proved unsatisfactory due to slack developed between the milled key slots in the hub and the keys of the two gears, in spite of use of a press fit at assembly. Soon after operation in an experimental machine this slack caused the two gears to lose their angular relationship to each other with consequent failure of the reverse mechanism. Since the relationship of the two gears must not vary more than one degree in order to maintain proper timing of the reverse drive with other gears, the original one-piece construction offered the most reliable and quickest answer to this problem. However, as mentioned, the


PROCESS SHEET FOR CLUTCH SHIFT PIN

FORMER DESIGN			NEW DESIGN		
Individual Operations	Bulk Operations	Operation	Individual Operations	Bulk Operations	Operation
1		Screw machine	1		Screw machine
3		Mill (2 angular & 1 cross mill)		1	Harden
1		Remove mill burrs		1	Cadmium plate
	1	Harden		1	Inspect
	1	Cadmium plate		1	Store
1		Wire brush			
	1	Inspect			
	1	Store			
6	4	Total operations	1	4	Total operations
1	4	Total operations (New Design)			
5	0	Total net saving in operations			

Fig. 5 — Left — Process sheet of shop operations required for counter reverse clutch key shift pin

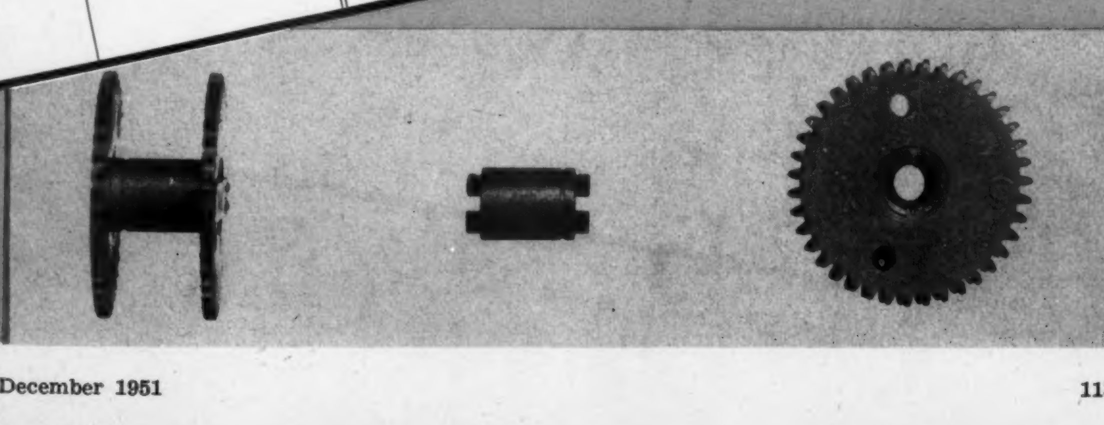


Fig. 6 — Below — New three-piece design for the reverse double idler gear. Staking of the keys insures a permanent tight fit in hub slots

cost was great due to the excessive screw machine and gear hobbing time required. Waste of material was also a costly disadvantage.

Staking Provides Answer

It was found that if these assembled idlers were staked in the keys to a depth of 0.016 to 0.020-inch, *Fig.* 6, the keys would expand sufficiently in the key slots of the hubs to provide an absolutely tight assembly. Extensive endurance tests proved this method to be highly satisfactory. This type of assembly reduced costs by nearly 65 per cent of that of the original one-piece construction despite the additional shop operations. The cost saving in this instance was accomplished by reduction in machine time, man hours, and material, *Fig.* 7.

The steps of simplification set forth herein may be successfully applied to numerous mechanisms. It is suggested that those in charge of production design examine the factory cost, rework and salvage data sheets on individual parts and assemblies, as it is often possible to reduce costs by a redesign which takes full advantage of available mass-production equipment and minimizes machine time and skilled man hours. Operations such as milling, hobbing, welding, etc., should be avoided in preference to the high-speed press, screw machine, and bulk operations which eliminate excessive handling. The result will be lower manufacturing cost as well as savings in many other more or less indirect ways such as tool upkeep. It should also be remembered that fewer parts mean fewer handling operations, thus favorably affecting stores, inspections, and service. The cost savings will even extend into production control, factory cost accounting, etc. In conclusion, considering scarcity of materials and other restrictions, it may be stated that simplification for the purpose of more economical mass production is a timely subject for consideration by every manufacturer.

PROCESS SHEET FOR REVERSE DOUBLE IDLER GEAR

FORMER DESIGN

Unit	Individual Operations	Bulk Operations	Operation
One-Piece Assembly	1		Screw machine
	1		Hob & burr one side
	1		Burr other side
		1	Harden
		1	Cadmium plate
		1	Inspect
		1	Store
Total Operations	3	4	

NEW DESIGN

Unit	Individual Operations	Bulk Operations	Operation
Three-Piece Assembly	1		Assemble complete & preliminary stakes to prevent falling apart prior to die riveting
	1		Die rivet
	1		Stake both ends of keys
		1	Cadmium plate
		1	Inspect
		1	Store
Hub	1		Screw machine
	1		C'sink one end
	1		Mill slot one end
	1		Ream hole
		1	Harden
		1	Inspect
		1	Store
Two Gears	2		Pierce, stamp & blank
	2		C'bore
	2		Repierce keyed hole & shave teeth
		1	String on wire with washers
		1	Harden
	2		Slick burr side
		1	Inspect
		1	Store
Total Operations	15	10	

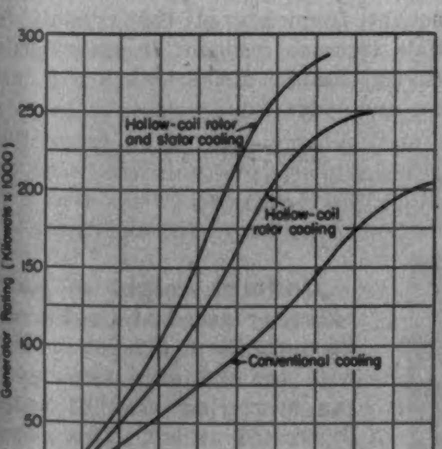
Fig. 7—Process sheet of operations for producing old idler gear design and new built-up design of lower cost

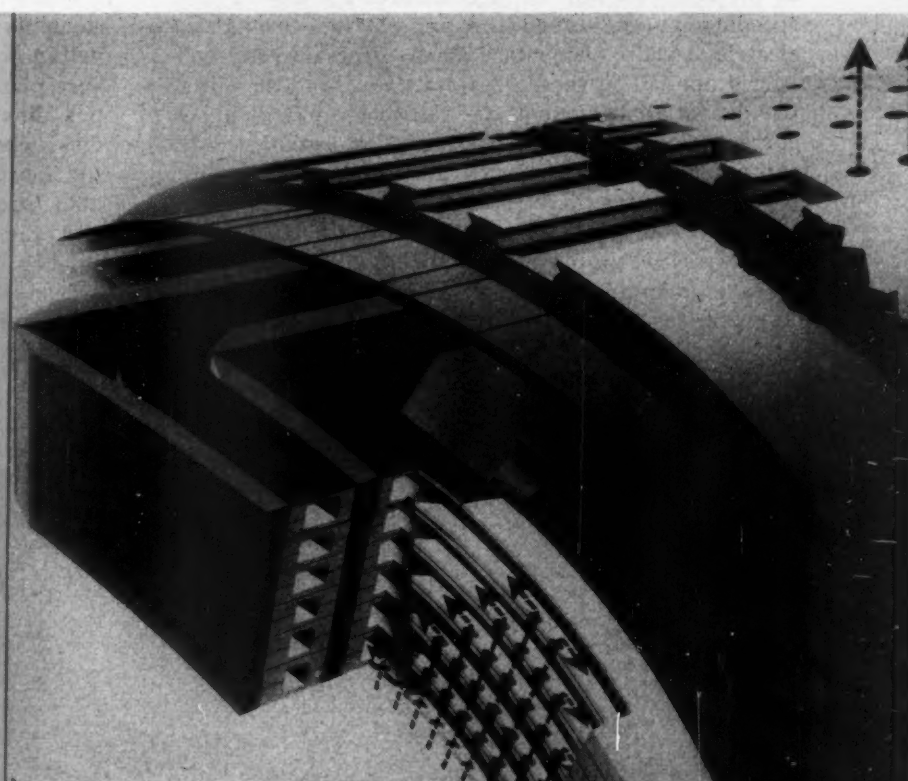
SCANNING the Field For Ideas

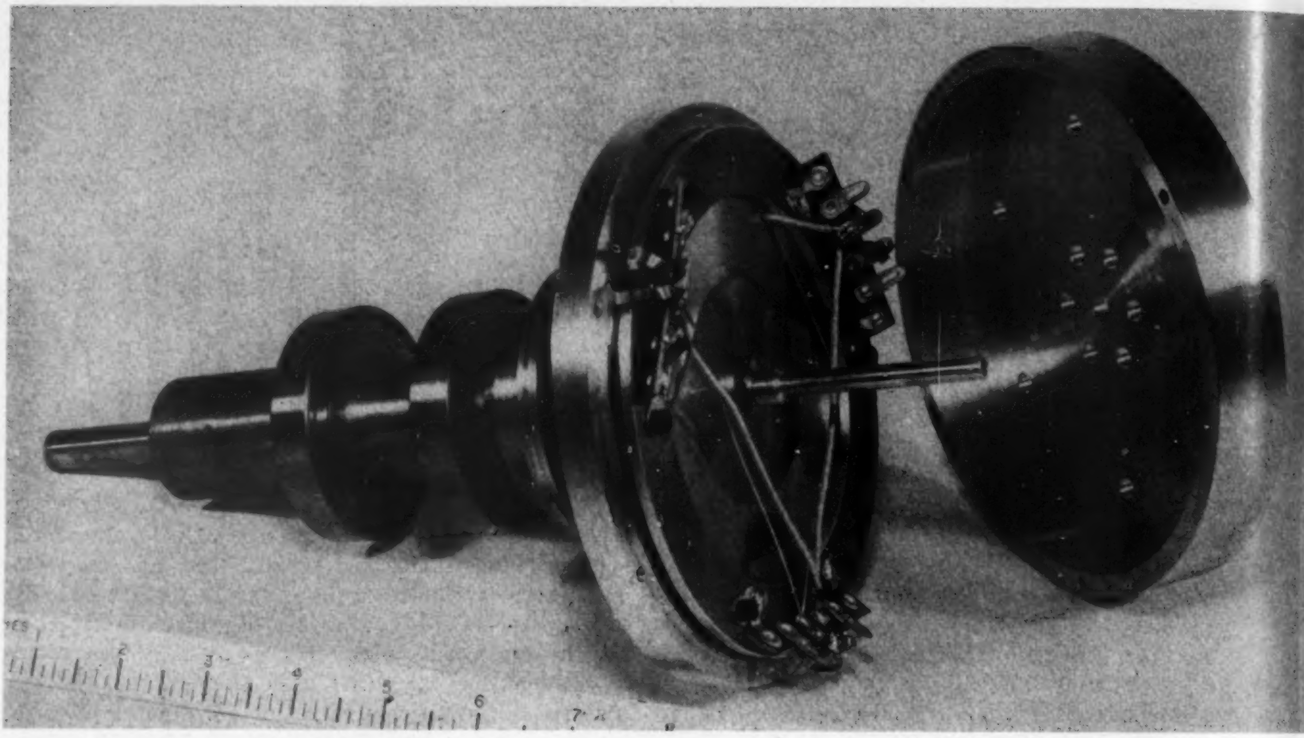
Internal cooling of large turbine generators with hydrogen will make possible capacity increases of 50 per cent and conservation of two critical materials, copper and steel. The new cooling technique consists of blowing hydrogen gas at high velocity through specially constructed hollow windings as shown in the cutaway view of a rotor below, bringing the cooling medium in direct contact with the copper in which the heat is generated.

Since this cooling method reduces the heat flow through the coil insulation, the temperature of the coils is determined by the temperature of the hydrogen gas and the heat transfer coefficient from the copper to the hydrogen. Thus it will be possible to pass more current through a given coil size because the additional heat can be dissipated quickly. Even though higher current densities in the copper reduce its efficiency, this loss is more than offset by the reduction of rotor surface losses and frictional losses in the bearings resulting from the smaller rotor.

Path of the hydrogen flowing through the rotor conductors is shown in the cutaway for a particular type of construction. The set of curves below show how hollow-rotor cooling increases the output rating of a generator compared with conventional designs. Also shown is anticipated rating for cooling both the rotor and stator. Two generators with internally cooled rotors are now being built by Westinghouse Electric Corp. and one with both rotor and stator cooling is being designed and will be tested in 1952.



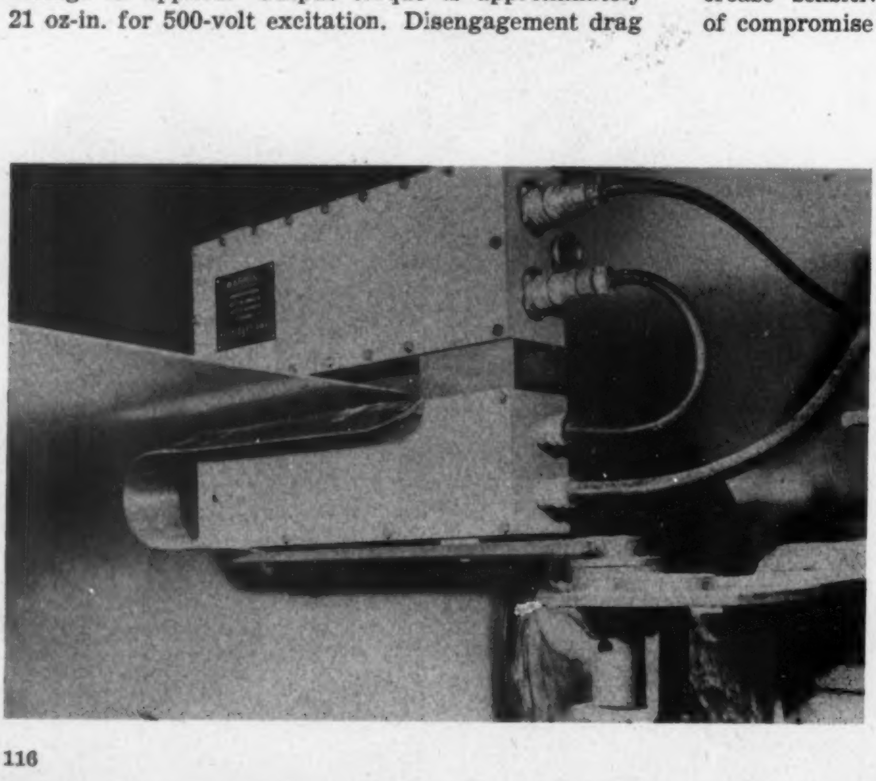




Crystal clutch, shown above with its cover plate removed, has an exceptional speed of response and requires almost negligible control current. Developed at the National Bureau of Standards for use in high-speed computers, the novel clutch employs three piezoelectric crystal elements. When direct-current voltage is applied to these crystals, they bend and press the output disk against the rotating input disk. No current flows, other than insulation leakage, after the applied voltage has charged the capacity of the crystals, creating no magnetic field.

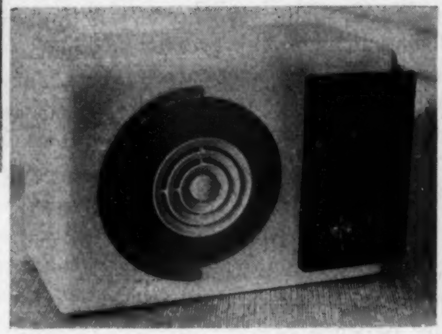
In this development model, the output shaft delivers useful torque in about 0.2-millisecond after voltage is applied. Output torque is approximately 21 oz-in. for 500-volt excitation. Disengagement drag or no-voltage torque, however, is 7.5 oz-in.

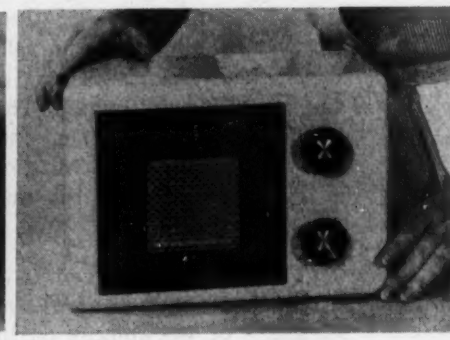
The output disk is located between two rotating members—a thin flexible crystal pressure plate and a heavier mounting plate or input disk. Three crystal elements are spaced at 120-degree intervals. Applied voltage causes the crystals to press against the pressure plate at a radius of 1.5 inches, pinching the output disk between the pressure plate and the input disk. Speed of response of the clutch is related to the inertia and loading of the output system, available torque, distance the pressure plate must move, and the resonant frequency of the crystal. Since thicker crystals increase resonant frequency but decrease sensitivity, design dimensions are a matter of compromise and judgment.



Uniform weight of paperboard, produced at the Fibreboard Products Corp., is being maintained with the aid of a beta-ray gage, the measuring head of which is illustrated at left. This gage, designed by General Electric, records the varying amounts of beta-rays absorbed by the board as it passes through the head of this noncontacting device. Amount of the rays absorbed varies with the weight of the board. Variations as slight as one per cent in the weight per unit are automatically indicated and recorded. Speed, consistency or temperature of the material have no effect upon the gage reading.

Ideas

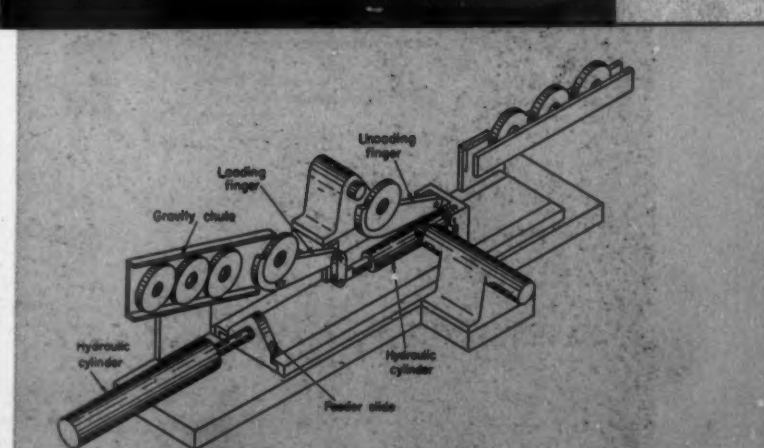




Various styling modifications, by employing a basic module, achieve the appearance of several diverse designs for the radio cabinets, shown above. Utilizing the same rectagular case, eight different cabinets may be developed through interchanging dials, knobs, speaker panels and other extraneous parts. Developed by the chemical division of General Electric Co., the radio may be placed in a horizontal or vertical position to give the appearance of entirely different cabinets.

Automatic transfer mechanisms between units, right, in a battery of machines eliminate all handling between machines, requiring only loading the first and unloading the last. These gear shaving machines, built by National Broach and Machine Co., are arranged so that no appreciable time is lost due to differences in machine cutting time. Although all machines are synchronized, each is individually controlled and may be operated individually whenever desired.

Principal elements of this simplified loader include a loading magazine having gravity feed and a sizing gage, an intermediate feeder slide and an incline discharge. The sketch, right, shows the work loading and unloading device for each machine. At the completion of a cutting cycle, the cutter stops and the pneumatically operated tailstock retracts to strip the workpiece and place it on the unloading finger of the feeder slide. Loading and unloading arms are connected by a link so that both units are moved simultaneously in the same direction by the loading air cylinder. When the loading cylinder raises the loading arm into position, a spring in the loading arm exerts sufficient force to hold the work.



Work to be processed rolls down the loading chute for the next machine and is positioned against a hinged spring stop which is mounted on the front cover of

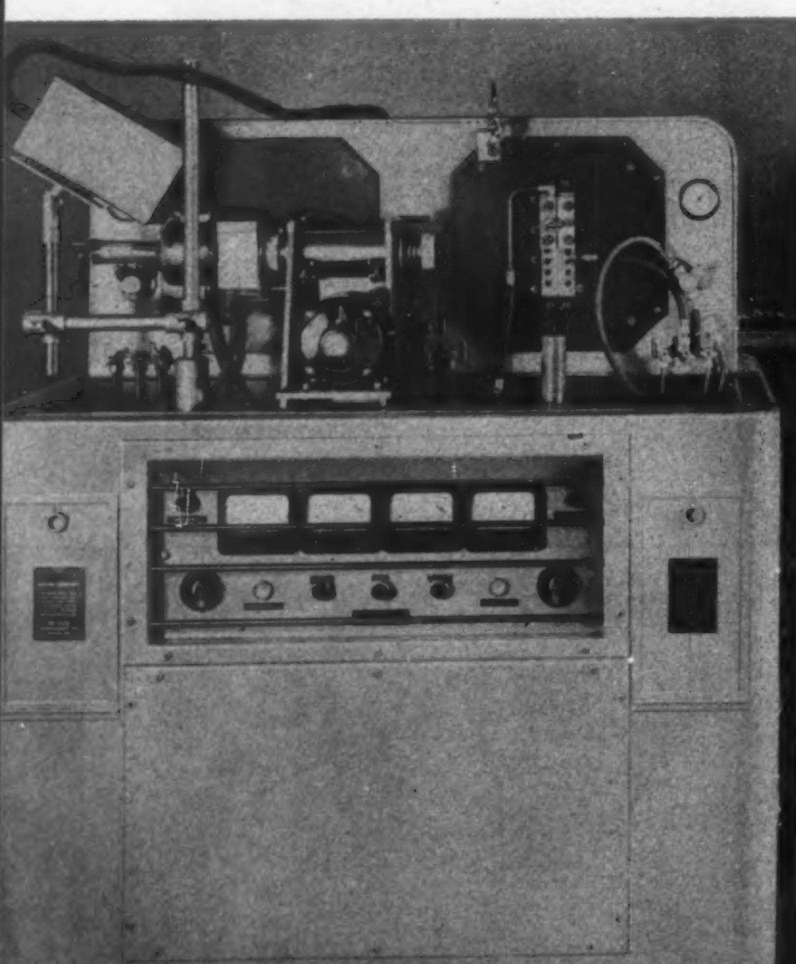
Ideas

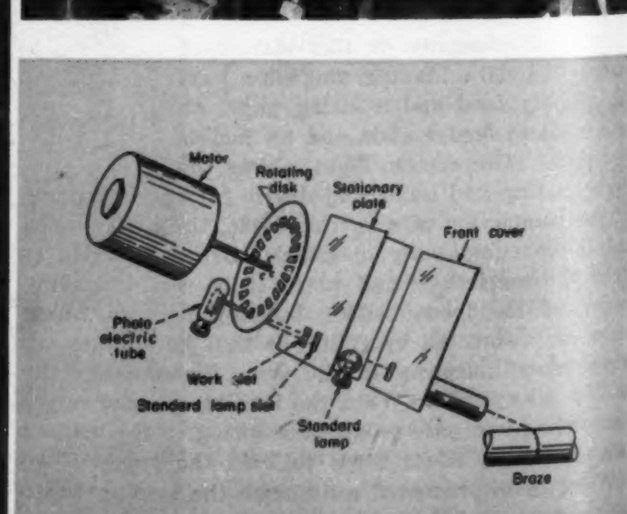
the chute, not shown in the sketch. This stop holds the work for loading and releases it when the greater force of the gripping finger on the loading arm forces the stop to swing away. The unloading chute of the last machine stores the completed parts until they are removed. If the chute becomes completely filled, a limit switch stops the machine until the chute is cleared.

Photoelectric control maintains constant temperature of workpieces during delicate brazing operations in the induction heater illustrated below. This control system compares radiation from the work with that of a standard lamp, controlling the power fed to the work by the induction heater. Developed by the Bell Telephone Laboratories, the system utilizes a spinning slotted disk to switch the phototube view alternately between the lamp and work for comparison, as shown in the schematic scketch below. As a disk slot scans across the two stationary slots, the successive positions of the slot produce a wave shape of the incident light on the phototube. When the work and standard lamp radiations are equal, constant illumination pulses are received by the tube and the control system modifies the current fed by the induction heater to maintain this balance during the brazing cycle. The photoelectric control unit, shown in the closeup view below, is mounted in a light-tight box, painted black inside to exclude extraneous light.

This control system has several advantages: The spectral character of the radiation from the work and the response characteristic of the phototube are closely alike; operating a standard lamp at the same color as the work makes the system independent of color sensitivity variations in the tube; variation of the radiation with the fourth power of the temperature aids control accuracy; and illumination of approximately the same portion of the tube cathode by both sources makes the control largely independent of tube changes.

In this system, the disk rotates at 1800 rpm, giving a frequency of 600 cycles per second from twenty slots. To produce a reference wave for performing the switching functions in the electrical circuit, a second tube and light source utilize another portion of the disk in a separated compartment.





SECRECY or PATENT?

Which shall the inventor choose? He cannot have both under U. S. patent law

By Albert Woodruff Gray
Jackson Heights, L. I.
New York

PATENT law provides that any person who has invented a new and useful machine may apply for a patent if the machine has not been "in public use or on sale in this country for more than one year prior to his application."

A few years ago the Federal Court of Appeals had before it an action by the Cincinnati Chemical Works involving the validity of patents relating to a rod mill, a revolving drum within which metal balls or bars effected a pulverization. The mill had been invented and put in operation in 1938 and a patent issued seven or eight years later. When the chemical company began using this apparatus the inventor demanded that they pay for its use. The company contended that the machine had been in public use for more than a year before the patent application had been filed and that the patent was void.

Concerning the effect of delay on the validity of the patent, the federal court said that the inventor's right to the patent is conditioned upon his refraining from exploiting his discovery competitively after the invention is ready for patenting. While the statute allows a limited period (at present one year) for preparation of his application, if he goes beyond that period of preparation he forfeits his rights.

If the mill designed by the inventor had been maintained in secrecy for a substantial period no valid patent could subsequently be granted, for the right to secrecy and to a patent monopoly are inconsistent. Both cannot be asserted with respect to the same machine. This is based upon the ground that an inventor may not extend his monopoly beyond the statutory period by keeping his invention secret.

A previous decision made by that court in 1946 was adopted here as authority. This court had said, "It is a condition upon an inventor's right to a patent that he shall not exploit his discovery competitively after it is ready for patenting; he must content himself with either secrecy or legal monopoly." It is true that for a limited period of two years he was allowed to do so, possibly in order to give him time to prepare an application; and even that has been reduced recently to one year. But if he goes beyond that period of preparation he forfeits his right regardless of how little the public may have learned of the invention.

Patent application for the rod mill was filed on August 6, 1942. From March, 1940, to August, 1941,

" . . . the inventor's right to patent is conditioned upon his refraining from exploiting his discovery competitively after the invention is ready . . . "

sixty-six commercial orders had been filled using this process. Although the invention had been carefully guarded as a secret it had nevertheless been employed, not for experimental, but entirely for commercial purposes.

The right to a patent had been forfeited by this delay and the public exploitation of the invention. "The inventor may continue for more than a year to practice his invention for his private purposes or his own enjoyment and later patent it," added the court, "but that is properly construed not an exception to

> *". . . he must content himself with either secrecy or legal monopoly . . ."*

the doctrine but that he is not then making use of his secret to gain a competitive advantage over others."

The litigation over a patent issued in 1818 served to establish these provisions of the patent law that deprive an inventor of his right to a patent when by the exploitation of his discovery under the protection of secrecy he seeks to overcome the seventeen year limitation to his patent monopoly.

The invention here was a hose so made that the joints were as capable as any other part in resisting pressure. Between the date the invention was perfected and the date the patent application was filed approximately 13,000 feet of this hose had been manufactured and sold by the inventor.

"If the inventor should be permitted to hold back from the knowledge of the public the secrets of his invention," said the United States Supreme Court of this provision of the patent law, "if he should for a long period of years retain the monopoly and sell his invention publicly and thus gather the whole profits of it, relying upon his superior skill and knowledge of the structure, then and then only, when the

> *". . . the inventor may continue for more than a year to practice his invention for his private purposes . . ."*

danger of competition should force him to secure the exclusive right, he should be allowed to take out a patent and by so doing exclude the public from any further use during the life of the patent, it would materially retard the progress of science and the useful arts and give a premium to those who should be least prompted to communicate their discoveries."

This limitation of one year in the filing of a patent application applies as well when a printed publication has carried a description of the patent as when it has been in public use or the invention or its products have been the subject of a commercial sale. The inventor must choose for the protection of his discovery either secrecy or the patent law. He cannot have both.

In 1903 George A. Macbeth perfected a process for the making of illuminating glass, which he held a secret until ten years later when a patent application for this invention was filed. Three years before this application was made, however, an employee of the inventor disclosed this process to a competitor. The competitor too, held the process a secret although the products of the process were marketed in the usual course of trade.

A few years after the patent had been issued Macbeth sought to enjoin an infringement by the General Electric Company. Here, said the court in denying the injunction application, was not a delay occasioned by sickness or by the poverty of the inventor. He did not withhold his application for the purpose of perfecting the invention. Instead, we have many years of delay after the invention was perfected, coupled with a continued and extensive use by the public for commercial purposes.

> *". . . if the inventor should be permitted to hold . . . the secrets of his invention . . . and sell his invention publicly . . . then competition force him to patent . . . it would materially retard the progress of science . . ."*

A famous case of another too long delayed patent application involved an invention relating to the rifling of cannon, of a William E. Woodbridge, in the middle of the last century. In 1852 Woodbridge, who was skilled in the science of projectiles, applied for the patent of an invention "applying to projectiles to be fired from a rifled gun for the purpose of giving to the projectile a rifled motion." His application was allowed. The following month Woodbridge wrote the Patent Commissioner, "I was informed in answer to my inquiry that upon the issue or order to issue of a patent it may be filed in the secret archives of your office (at the risk of the patentee) for such time as he may desire. I wish to avail myself of this privilege when my patent may issue, in order that my ability to take out a patent in a foreign country may not be affected by the publication of the invention."

The Patent Office replied that a patent had been ordered to issue on Woodbridge's application and that in accordance with his request the papers were filed among the secret archives of the office subject to his directions as to the time of issuing the patent. Nothing was done either by Woodbridge or the Patent Office from 1852 until December 31, 1861. In the meantime the impending storm of the Civil War

had broken and patents for the rifling of cannon had taken on a value they had not possessed nine and a half years before.

On that date Woodbridge wrote the Commissioner of Patents calling his attention to this 1852 patent. "I have allowed it to remain until the present time, it being only lately that any immediate opportunity of rendering it pecuniarily valuable has occurred."

The reply of the Patent Office that the patent would be ordered to issue was followed three weeks later

> ***". . . an application for a patent through which the inventor deliberately postpones . . . the beginning of the term of his monopoly . . . is an evasion of the statute . . ."***

by a second letter that the length of time this invention had been allowed to slumber was a bar to the issuance of the patent; that for nearly ten years he had suffered his application to remain locked up not merely beyond the reach of the public but beyond even the cognizance of the examiners and other officers of the department; that in the meantime many patents had been issued for the same invention and yet his sole reason for this delay and silence was that until recently he had supposed the invention would not prove remunerative.

This rejection of the application was appealed to the Board of Examiners. On adverse decision by that body, a further appeal was made to the Commissioner of Patents who sustained the rejection of the application and in 1880 the controversy came before the United States Supreme Court for decision, which affirmed the previous rulings.

Twenty years later Congress passed a special act by which this Woodbridge claim for compensation from the United States for the use of his invention in the rifling of cannon, was referred to the Court

> ***". . . it was the legislative intent that the term should run from the date of issue . . . at the end of that time the public . . . freely use the invention . . ."***

of Claims. The act, however, carried the clause, "Provided however, that the said court shall first be satisfied that the said Woodbridge did not forfeit or abandon his right to a patent by publication, delay, laches or otherwise."

The decision of the Court of Claims, adverse to the inventor, was appealed by the representatives of his estate, to the United States Supreme Court. Sustaining the decision of the Court of Claims, that court in conclusion summarized this law in relation to the delay in the filing of patent applications and the consequent forfeiture of the right to a patent.

"It was the legislative intent that the term should run from the date of the issue of the patent and that at the end of that time the public might derive from the full specifications required in the application accompanying the patent, knowledge sufficient to enable it freely to make use of the invention. It is true that a patentee is not obliged either to make use or vend his invention during the period of his monopoly. Congress relies, for the public benefit to be derived from the invention during the monopoly, on the natural motive for gain in the patentee, to exploit his invention and to make use and vend it or its products or to permit others to do so for profit. The importance in working out the purpose of Congress of keeping the inventor's monopoly within the term for which the patent is granted, is thus shown to be capital. An application for a patent through which the inventor deliberately and without excuse, postpones beyond the date of the actual invention, the beginning of the term of his monopoly and thus puts off the free public enjoyment of the useful invention, is an evasion of the statute and defeats its beneficient aim."

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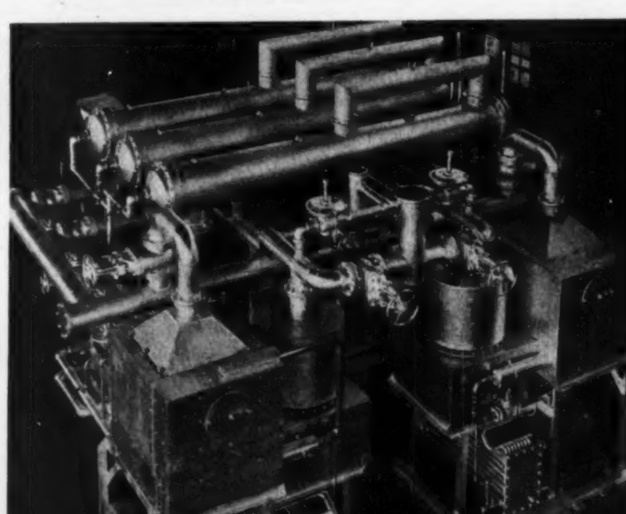
2. Huszar v. Cincinnati Chemical Works, 172 Fed. 2d 6, Feb. 3, 1949.
3. Metallizing Engineering Co. v. Kenyon Bearing & Auto Parts Co., 153 Fed. 2d 516, January 10, 1946.
4. Pennock and Sellers v. Dialogue, 2 Peters (U.S.) 1.
5. Macbeth-Evans Glass Co. v. General Electric Co., 246 Fed. 695.
6. Woodbridge v. United States, 263 U.S. 50.

Largest Atmosphere Generator

FOR the clean annealing of sheet steel in box type annealers, the largest atmosphere generating unit ever produced by Surface Combustion Corp., Toledo, O. is being delivered to Jones and Laughlin Steel Corp. Employing the partial combustion of natural gas, this unit will have a capacity of 35,000 cu ft of DX gas per hour.



Reducing Noise in Machines

. . . how to measure and analyze sources to effect quiet operation

IN THE past decade, the control and reduction of industrial noise has been recognized as a serious problem. Some of the harmful effects of noise have been partially evaluated, while others remain unevaluated and controversial. Data are now becoming available on levels of noise which result in hearing impairment[1], but the deleterious effects of noise on worker efficiency, fatigue, morale, and accident prevention, while admitted, are not fully understood. As these effects become known, management will necessarily consider noise control as seriously as it does other safety and morale problems.

Noise control has so many aspects that the scope of this article will be limited to a discussion of the methods of measurement, analysis, and reduction of noise radiated to the air by machines, *Fig.* 1. Machinery vibration problems are not included, except as such vibrations contribute to radiated sound.

Any discussion of measurement of physical properties of sound or noise must start with the performance of the hearing mechanism, since this sensory system will perform the final evaluation of any noise reduction program.

The human ear performs as a frequency analyzer, as an indicator of loudness, pitch, and timbre, and as a sound locator. The frequency range of normal hearing extends from about 20 to 18,000 cycles per second, a range of about 10 octaves. The range of sound pressures detectable by the ear is greater than a million to one, and under favorable circumstances sound pressures smaller than 10^{-10} atmospheres can be heard.

Of the physical properties of sound evaluated by the ear, the only two which can be measured with relative ease by means of acoustical instruments are, sound pressure and frequency. Loudness of noise, as judged by the ear, depends on the sound pressure, but the relationship is not simple, for it depends also on the freqûency spectrum. Apparent pitch of a noise judged by the ear depends on the frequency spectrum but, in this case, the sound pressure also affects the subjective judgment. These facts point up the complex nature of the measurement problem and indicate the difficulties faced by instrument de-

[1] Karl D. Kryter—"The Effect of Noise on Man," *Journal of Speech and Hearing Disorders*, Monograph Supplement No. 1, 1950, Interstate Printers and Publishers, Danville, Ill.

Fig. 1 — Echo-free room specially designed for precise acoustic measurements. While such a room is desirable for research in noise reduction, it is usually possible to make adequate noise measurements in simpler less expensive rooms

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signers in attempting to develop noise measuring equipment which yields data correlated with subjective judgments by the ear.

Relationship between sound-pressure level (customarily measured in decibels) and loudness (measured in phons or sones) for sounds consisting of a single frequency is well known. The contours of equal loudness shown in ***Fig.*** 2 demonstrate this relationship. A summary of the information contained in these contours is as follows: For low sound-pressure levels, a given loudness level requires much greater sound pressure at low and high frequencies than at frequencies around 1000 to 2000 cycles per second. For higher sound-pressure levels, the loudness level varies much less with frequency. In other words, the shape of the loudness level contours changes from concave upward to nearly flat as the loudness increases from 0 to 120 phons.

Designers of sound-level meters have attempted to produce devices to indicate the loudness of steady sounds by providing three frequency response characteristics for the instrument corresponding to the 40, 70, and 100 phon equal-loudness contours. The user then selects the frequency weighting network most suitable for the sound-pressure level being measured and reads a "weighted sound-pressure level" on the output meter. While the sound-level meter is still the basic instrument for noise measurement, it is universally agreed that, except for measurement of single pure tones, results obtained from the weighted network are often considerably in error in representing numerically the loudness of a noise. The reason for this difference lies in the fact that for sounds consisting of many closely spaced or random frequency components the ear judges loudness in an even more complex manner than that described. No meter is yet available, therefore, which can provide a single number describing the loudness of all types of complex noises.

Even though no satisfactory loudness meter exists, there are various satisfactory techniques for making quantitative measurement of airborne noise. The choice of the exact method depends on the characteristics of the noise to be measured, but in all cases

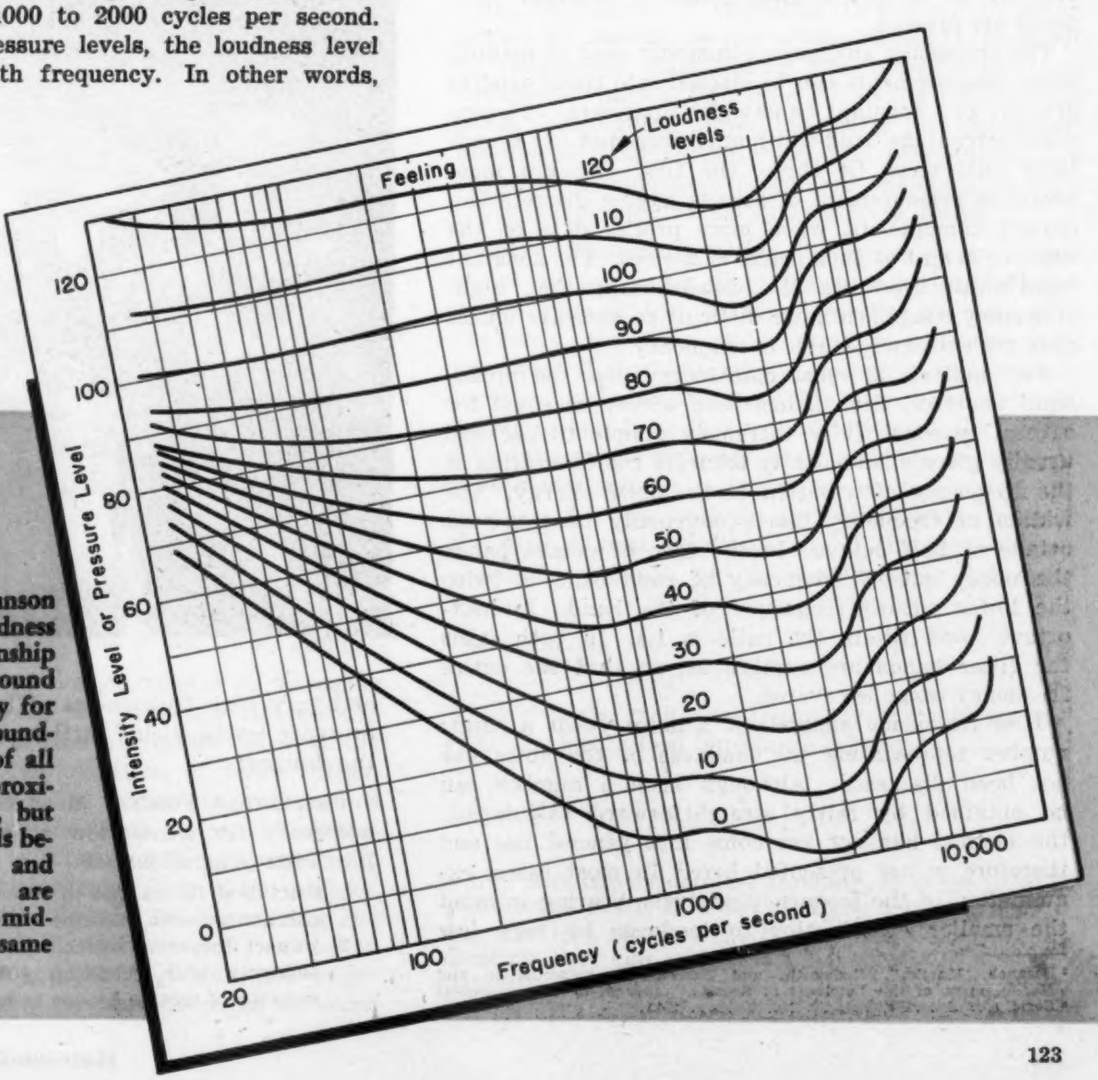


Fig. 2 — Fletcher-Munson contours of equal loudness showing the relationship between loudness, sound pressure, and frequency for pure tones. At high sound-pressure levels, tones of all frequencies have approximately equal loudness, but for sound-pressure levels below about 70 db, low and high-frequency tones are much less loud than mid-frequency tones of the same pressure level

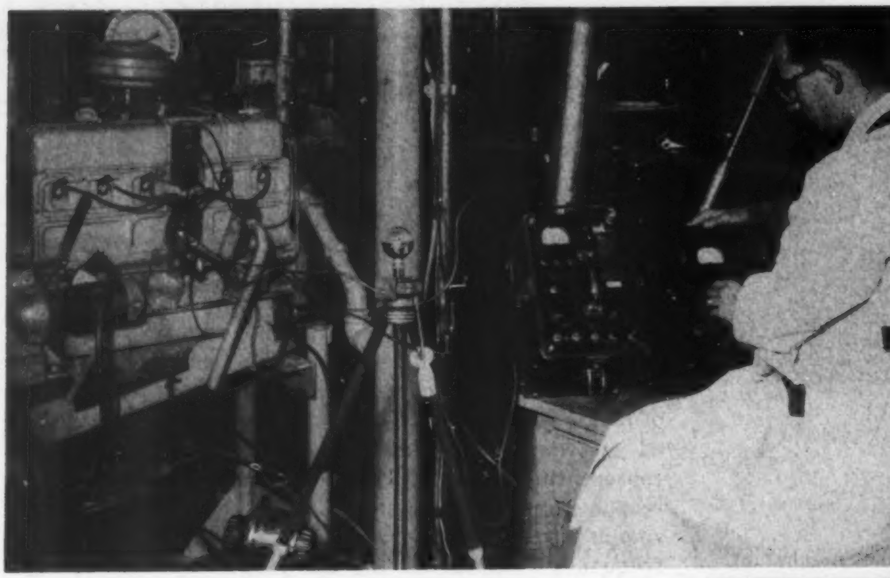


Fig. 3—Left—Sound-level meter and octave band analyzer in use. Overall sound level is indicated by meter at the left, while the sound level in selected octave band is indicated by the analyzer which is shown at the right

Fig. 4—Below—Use of stethoscope for determining local sources of noise in a machine and for making qualitative observations regarding the relative contribution of various noise sources

the technique consists of some form of frequency analysis of the complex sound.

Machinery noises may be classified generally as broad band in character (having many random frequency components) or as composed of frequency components which may or may not be harmonically related. The noise of fans and blowers is generally broad band, while gears, saws, and other machines have spectra containing discrete frequency peaks. The ear is usually a good judge of whether such peaks are present.

The frequency analyzers commonly used in making noise measurements can be classed into three general groups: (1) constant band-width analyzers, (2) constant percentage band-width analyzers, and (3) broad-band analyzers. Of these, the first two are most useful in measurement of sounds having discrete frequency components, when more precise data on the relative height of such peaks is desired. The constant band-width type has the disadvantage that high-frequency components are difficult to measure unless they are extremely stable in frequency.

For analysis of most machinery noise the broad-band analyzer, *Fig.* 3, has been widely accepted for several reasons. It is extremely simple to use and usually gives a sufficiently accurate representation of the frequency distribution of the noise energy. The widths of frequency bands commonly used are an octave or half octave. In the case of octave bands the upper cut-off frequency of each band is twice the lower cut-off frequency of the band. In half-octave band filters the ratio is 1.4. In both cases the filter bands are contiguous, so that the entire frequency range is covered.

How frequency analysis of a noise yields a single number representing the loudness of the noise has not been discussed. Although such a number can be obtained by fairly straightforward calculation, the method has not yet come into general use and therefore is not presented here.[2] In most cases, examination of the frequency analysis, bearing in mind the smaller contribution to loudness by very low and very high frequencies at low and middle sound-pressure levels, yields sufficient information to guide the designer.

Excitation Forces: Most of the exciting forces necessary for generation of noise can be grouped into a few general classes:

1. Frictional forces due to rubbing, sliding or rolling contact between machine members
2. Impact forces in which machine members contact suddenly with resulting change in direction or velocity of motion by one or both members

[2] Beranek, Marshall, Cudworth, and Peterson — "Calculation and Measurement of the Loudness of Sounds," *Journal of the Acoustical Society of America*, Vol. 23, No. 3, May, 1951.

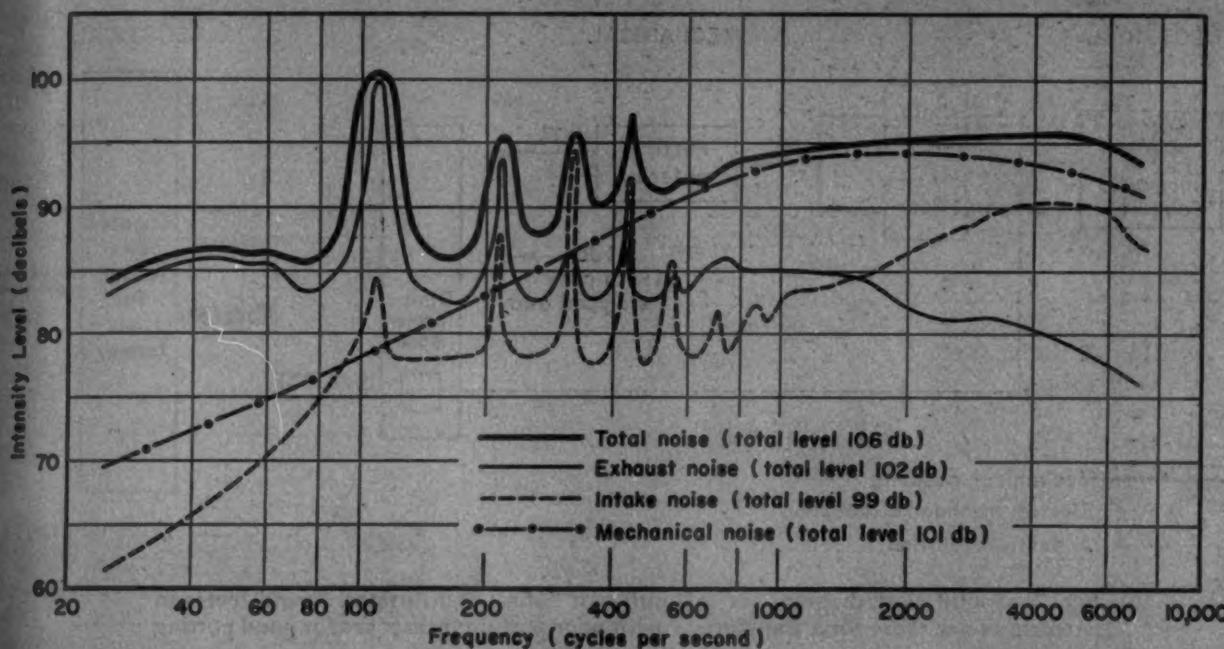
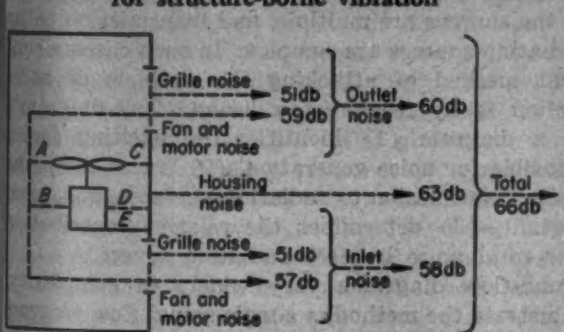


Fig. 5—Above—Frequency analysis of noise of a small internal combustion engine determined by a constant percentage band width analyzer. Various components of the total noise were obtained by operating the machine under its own power and with external drive

Fig. 6—Below—Sound-flow diagram for a portable electric heater. Dotted lines indicate paths for air-borne sound; solid lines indicate paths for structure-borne vibration



3. Vibratory forces in which rotating or vibrating members radiate sound
4. Forces due to turbulence associated with high fluid velocity in ducts, at fan blade tips or at grilles.

First step in the reduction of noise is to determine what the exciting forces are and their relative importance. Reduction of the excitation force is the most direct method for reduction of noise output.

In evaluating the relative importance of various excitation forces, the stethoscope, *Fig.* 4, and stroboscope are helpful. It is often helpful, if possible, to make measurements with various parts of the machine operating independently, *Fig.* 5. In determining the exciting forces, one must exercise care not to be misled by secondary sources in which the exciting force is transmitted by various paths to some other part of the machine which acts as radiator of the noise.

If the sources of excitation forces can be determined, all possible means of eliminating them should be considered. Substituting fiber gears where load conditions permit, dynamic balancing of rotating parts, redesigning impacting parts to incorporate the use of damping materials, and substituting fans or grille of improved design are examples of noise reduction by elimination of excitation forces.

Sound Radiation: Often the noise energy source is not the same part of the machine as the radiation source from which the sound reaches the air. It is necessary, therefore, to be familiar with the basic principles of sound radiation. Magnitude of the sound pressure radiated from a vibrating object depends, among other factors, on the motion of the object. The mechanical property of a machine part which resists this motion is known as its mechanical impedance, Z. The mathematical relationship between the displacement amplitude, A, of the part, its mechanical impedance, and the exciting force F, is given by

$$A = \frac{F}{2\pi f Z} \qquad (1)$$

where f is the excitation frequency in cycles per second. The mechanical impedance is given by

$$Z = R + j\left(2\pi f M - \frac{K}{2\pi f}\right) \qquad (2)$$

where R is the mechanical damping, M is the mass of the moving parts, K is the stiffness acting to restore the part to a state of equilibrium and j is $\sqrt{-1}$, indicating that the mechanical impedance is a vector quantity.

Equations 1 and 2 indicate that such a system will

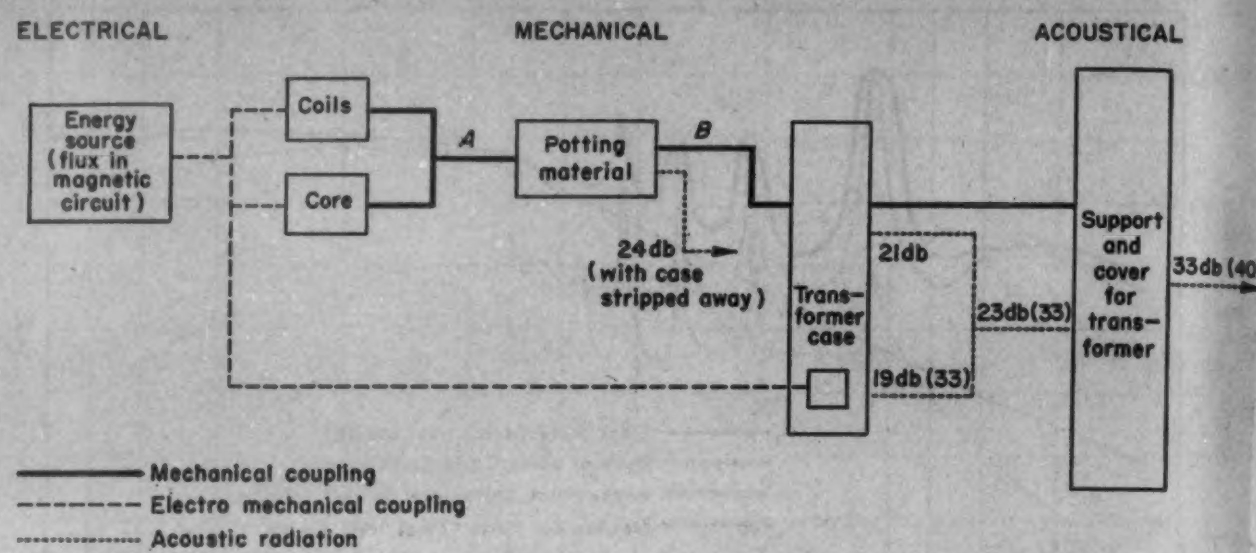


Fig. 7—Sound flow diagram for a fluorescent ballast transformer. Sound levels in parenthesis are those for a transformer with poor potting; others are for good potting

have minimum impedance and therefore maximum displacement amplitudes at a frequency such that the mass reactance is equal to the stiffness reactance. This frequency is known as the resonant frequency and is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{K}{M}} \qquad (3)$$

One can decrease the displacement amplitude at a particular frequency by increasing the mechanical impedance. Equation 2 indicates that this can be done by increasing the mechanical damping or by changing the relationship between the mass and the stiffness. The latter method will change the resonant frequency but will not reduce the displacement amplitude at resonance, since the mass and stiffness reactances cancel at that frequency. In actual vibration problems, noise radiating surfaces usually have many resonances which may be, but are not necessarily, harmonically related.

Effects of Surface Radiation

Vibration amplitude is only one factor upon which radiation of sound from a vibrating surface depends. A second factor is the radiation resistance which the air presents to the vibrating surface. The acoustic power dissipated in the air is proportional to the radiation resistance existing at the surface. This resistance increases approximately as the square of the area of the surface. For a given exciting force the vibration amplitude is inversely proportional to the area, so that increasing the area of the radiating surface results in increased sound radiation. This principle is, of course, recognized by designers of musical instruments, who employ sounding boards to increase the radiating area. The same principle sometimes disappoints an engineer who, in attempting to quiet a noisy machine, covers it with a housing, only to find the noise level increases after this treatment.

Sound-Flow Diagram: In a few sound producing devices, the vibrating sources and the radiation sources are the same. Much more frequently, however, the sources are multiple, and transmission paths to radiating sources are complex. In such cases, a convenient method of attacking the problem of noise reduction is by means of a "sound-flow diagram". Such a diagram (1) identifies the exciting forces responsible for noise generation, (2) traces the paths of noise transmission to radiating surfaces, and, most important, (3) determines the relative contribution to the total noise by each radiation source.

Sound-flow diagrams vary widely in complexity. To illustrate the method, a simple sound flow diagram for a hypothetical portable electric heater will be examined. The heater consists of a direct-drive electric fan and electric heating element enclosed in a sheet-metal housing with intake and discharge grilles. The schematic diagram of *Fig*. 6 shows the result of a series of noise measurements on the unit and would be of great value in attempting to quiet the unit. This diagrammatic example will be considered in some detail to show its usefulness.

Suppose that the noise output of the unit operating in a quiet room is 65 db. (It would be still better to express the noise output in loudness units determined from an octave-band frequency analysis.) A series of measurements determine the noise sources, transmission paths, radiating surfaces, and the relative importance of these factors. In this simple case there are only two primary sources of noise—the turbulent air flow caused by the fan and the rotational motion of the fan motor. Referring to *Fig*. 6, fan blade noise, *A*, adds to the motor noise, *B*, and the re-

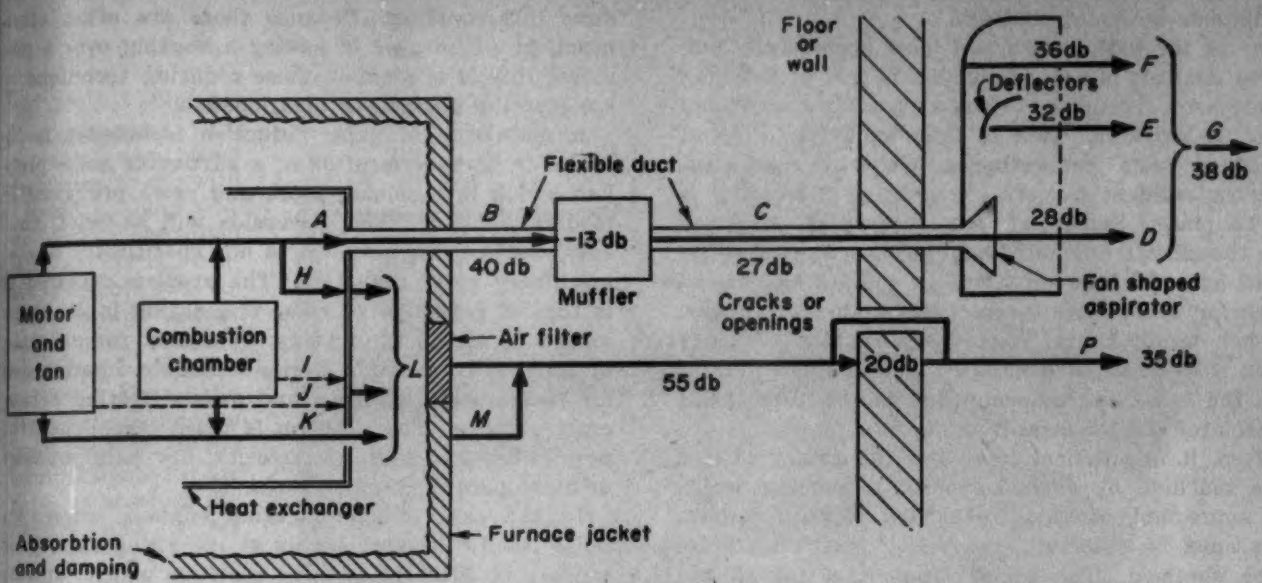


Fig. 8—Sound-flow diagram for a forced hot-air furnace. Solid lines represent air-borne sound paths; dashed lines show paths for mechanical vibrations

sulting noise escapes through both intake and exhaust grilles. The airborne sound inside the housing is also coupled to the housing, *C* and *D*.

Fan and motor vibrations are mechanically coupled to the housing through a motor support indicated by the solid line *E*. This results in vibration of the housing and radiation of sound. In this case as is often true in air-flow systems, there are secondary sources of noise at both intake and outlet grilles because of turbulent air flow across the grille surfaces.

Suppose both inlet and outlet grilles are covered with heavy sheet metal, plywood, or other material whose sound transmission loss is considerably greater than that of the housing. Then the noise level becomes 63 db, and this is attributed to sound radiated by the housing. Next, inlet and outlet noise are measured separately. The fan and motor noise contribution of each outlet can be determined by covering alternate grilles. The contribution of noise generated by the grilles can be determined by connecting a silencing duct to an outlet while making noise measurements at the other with and without the grille in place.

Determining Quantitative Measurements

Other experiments, such as measurements with the entire cover removed, can be performed to refine the accuracy of the data. The final result is a sound-flow diagram more or less complete with quantitative measurement of all components of the total noise. The analysis shows that noise radiated by the housing makes the greatest contribution. Reduction of this factor by a great amount, however, would result in a noise level not lower than 61 db (the sum of inlet and outlet noise). The noise generated at the inlet and outlet grilles contributes little to the noise. However, if the fan and motor noise is quieted by as much as 6 db, the grille noise will become important.

Discussion of the sound-flow diagram could be carried into considerably greater detail, but it is believed that the general principles have been described sufficiently. One application to a noise analysis problem will serve better than extensive discussion to indicate its usefulness.

Some examples of more complex sound-flow diagrams which have resulted from actual noise reduction problems are shown in *Figs*. 7 and 8. The principles involved are identical to those previously described. Ingenuity and good judgment in choosing and performing experiments are essential to the successful use of this tool.

Techniques for Noise Reduction: After making a complete analysis of the exciting forces, transmission paths, and radiation surfaces of the noise of a particular machine, the engineer is faced with the problem of making design changes which will result in reduced noise output. He must compromise often with factors of weight, space, maintenance, or economics. In many cases, however, practical solutions of surprising simplicity and practicality can be found. The methods and techniques for noise reduction must necessarily be discussed in general terms. Only a consideration of a particular problem will reveal the best method or combination of methods for achieving the desired quieting.

It was shown earlier that increasing the mechanical resistance to vibration would reduce vibration amplitudes and noise radiation. This technique is particularly useful in reduction of noise due to frictional or impact forces. Typical examples of methods of increasing mechanical resistance are substitution of "dead" or nonmetallic parts where strength or

wear requirements permit, the use of laminated metal and fabric or other composite materials, and the use of adhesive deadening coatings.

One of the best known and most successfully employed methods of noise reduction is that of reducing the mechanical coupling between vibration sources and radiating surfaces. This is done by substitution of flexible or "soft" connecting members for rigid ones. Utilizing resilient mounts for rotating machinery is commonplace. Somewhat less frequently employed even though often equally successful, is the use of resilient material between vibration sources and hoods, panels or other enclosures. The stiffness criterion for such decoupling is: The lowest vibration frequency which is to be isolated must be several times greater than the resonant frequency due to the stiffness of the isolator and the mass it supports.

Often, it is practical to reduce the noise radiated by a machine by enclosing it in a housing which has appreciable sound attenuation. Several precautions must be observed, however, if good results are to be obtained. The sound attenuation for all but the lowest frequencies depends mainly on the mass of the material, so that extremely flimsy construction cannot be used. The housing must be continuous and impervious. If air intakes or other openings are required, silencers for these openings must be used if the housing is to be effective. Also, the housing must be mechanically decoupled from the vibrating machine.

Coupling through the air path between the machine and the housing may also be significant. Lining

Fig. 9—Specially designed directional microphone for measuring the noise of a machine operating in the presence of ambient noise from other sources

the housing with acoustical material or increasing the space between the machine and housing will reduce this coupling. Because there are often other practical advantages in having a housing over a machine, this is a common noise reducing technique in spite of the difficulties mentioned.

A discussion of noise reduction techniques is incomplete without mention of a particular noise problem which is becoming more and more prevalent in modern industry. The discussion will be brief, however, because the problem is not specifically one of machinery noise reduction. The problem referred to is that of reduction of noise originating in or transmitted by air ducts or pipes. It occurs, for example, in internal combustion engine exhausts, heating and air conditioning systems, and ground testing of aircraft engines. The problem is often complicated by requirements of high air velocity, low back pressure or high operating temperatures.

In the case of reciprocating engines where the noise occurs in short bursts at the firing rate, good use can be made of metallic mufflers which "smooth out" the noise pulses, removing the high frequencies. In ventilation and heating systems noise can usually be controlled by use of (1) acoustical lining in ducts, (2) mechanical isolation between circulating fans and ducts, (3) ducts of sufficient cross section to keep air velocity below about 1000 feet per minute, and (4) proper design of outlet grilles.

Problems involved in silencing jet engine test cells are extremely difficult and the solutions are expensive. A typical jet engine exhausts 150,000 cfm at 1200 F and a noise level of 150 db. This noise must usually be reduced to 100 db or less. It is easy to appreciate that the silencing structure may be several times the size of the test cell proper. The silencing structures which have been employed are, acoustically treated ducts with reverse bends and expansion plenum chambers, egg-crate structures of acoustical material in ducts or stacks, and other special designs. Much research is still needed in this field, and it is believed that more effective and less complicated silencing devices will be developed.

How To Measure Noise

MEASUREMENT METHODS: One of the first questions which arises when the noise of a machine is to be measured is where to measure. Often the machine is situated in a large reverberant room, so that reflected sound from the walls combines with direct sound from the machine to produce standing waves at many frequencies. Since this often cannot be avoided, the measurement locations should be chosen close to the machine, in general 1 to 3 times the largest dimension of the machine. In such cases, measurements in octave bands usually yield more useful data than those made with narrow band analyzers, since variations in sound level at single frequencies due to standing waves are averaged by the many frequencies present in each band. It is wise to make a series of measurements around the machine, with the microphone at a height approximately that of the worker's ears. The reader is warned, however, that little is gained by accumulating pages of data,

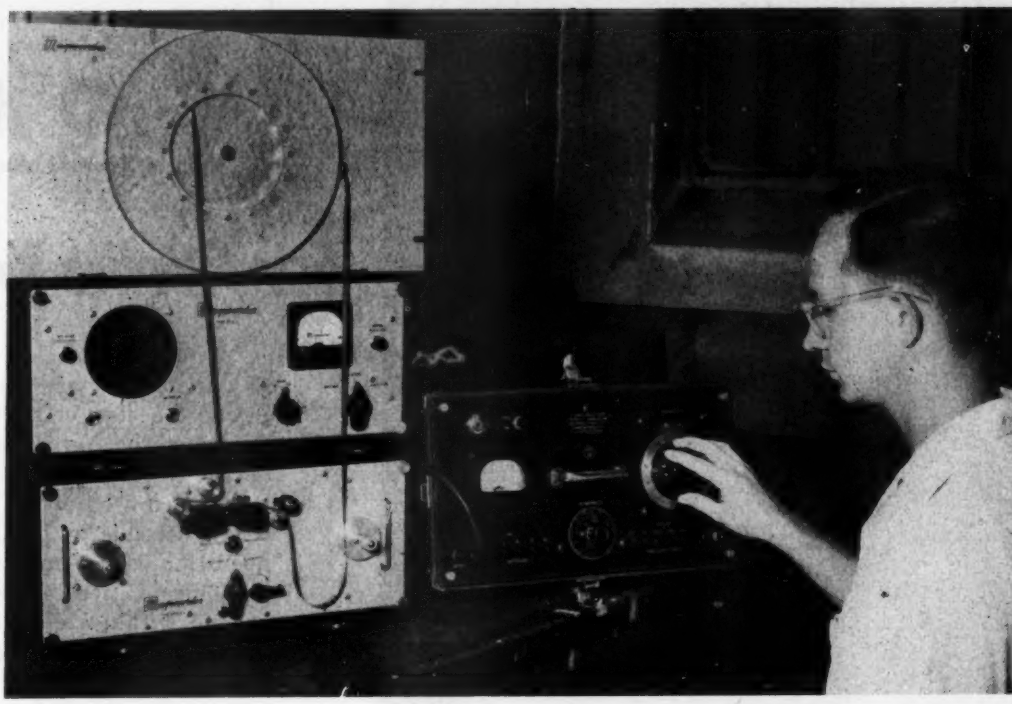


Fig. 10 — Magnetic tape recorder with continuous loop mechanism in use with a sound analyzer. A previously recorded noise is played continuously by the recorder, whose output is fed to a constant percentage bandwidth analyzer. The analyzer meter indicates the sound pressure of the recorded signal for the frequency at which the analyzer dial is set

and that many a beginner has been led to erroneous conclusions by reading significance into minor variations in noise level at different locations around the machine.

Another problem which arises in measuring the noise output of a machine is the fact that other sources of noise exist in the same area which are comparable in magnitude to the one it is desired to measure. The best solution to this, of course, is to eliminate the interfering noise. In general, if the interfering noise is 8 to 10 db lower in all the frequency bands, it will not seriously affect the data. If it is impractical to eliminate the interfering noise source, use may sometimes be made of a directional microphone, *Fig*. 9, or of a horn or a parabola to give a nondirectional microphone directional sensitivity. A horn with a 24-inch bell will be directional at frequencies above 500 cps, which contribute most to loudness and speech interference.

Frequently, a noise is intermittent, with only a few seconds duration. In other cases the noise may vary slowly with time throughout some acceleration or other operating cycle. In such cases, a good quality magnetic tape or wire recorder, *Fig*. 10, is useful. In this way the frequency analysis can be made from the recorded loop with a high degree of accuracy. Such recordings have the additional value of providing a permanent record of a noise which can be compared with later recordings to demonstrate the effect of noise-reducing treatment.

Thus far attention has been devoted chiefly to the measurement of machinery noise at the operating location of the machine to obtain data for use in reducing the noise radiated to surrounding areas. In many cases the object of noise measurement is to evaluate, compare, or reduce the noise of machines such as appliances being produced for sale to the public. For such purpose it is often desirable to provide a special room for sound measurements. A sound room should be designed to fit the particular measurement involved, and may vary in complexity from a small, untreated, quiet room to a rubber-supported anechoic (echo-free) chamber, *Fig*. 1. In any case, construction of such a room should be preceded by a careful analysis of the measurement problem by exeprienced acoustical engineers.

Evaluating Sound Annoyance

Certain subjective properties of noise exist which to date cannot be described numerically. These properties have considerable effect on the annoyance value of sound. For example, an intermittent noise or one with a spectrum shifting in a random fashion will be judged more annoying than a steady noise. Noises containing many high-frequency components (hisses, screeches, etc.) are generally more annoying than those composed of low frequencies (thuds and rumbles). It is generally true also, that a worker is less annoyed by the noise of his own machine which he has learned to associate with its proper operation, than by extraneous noises which he cannot identify.

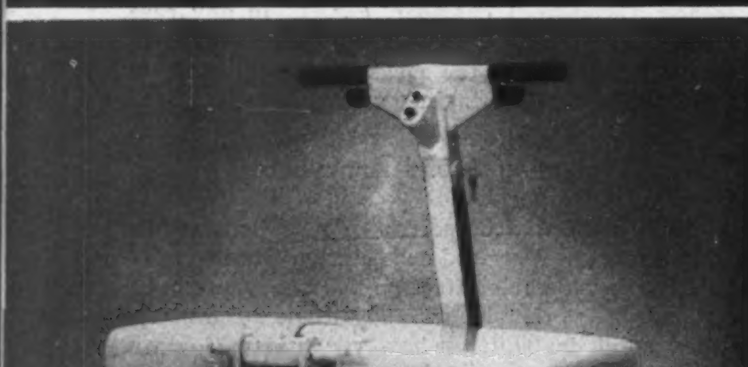
Some of the psychological problems cannot be attacked by known engineering principles. Their solution must await the results of future psycho-acoustic research. It is safe to say, however, that reduction in loudness, which results from properly interpreted acoustical measurements and application of known noise reduction techniques, will lessen the likelihood of industrial deafness and reduce the annoyance and fatigue of the worker who is obliged to work in a noisy environment.

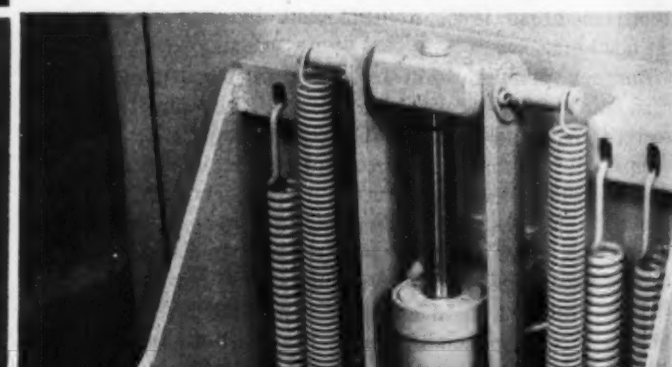
In this article, the more common methods available to the engineer undertaking the problem of quieting a noisy machine have been considered. Variations and combinations of these principles will almost always be necessary in a particular application, and the beneficial results will be dependent on the accuracy with which the noise problem is analyzed and evaluated.

CONTE

Grip Coupling Increases Maneu lity

● Automatic close coupling arrangement highlights the new motorized tractor unit shown. Designed for towing material handling trailers of the various castered types, the tractor can be coupled securely to suitable trailer frames in a few seconds with minimum effort. In actual operation with a large trailer it is possible, when gripping the non-castered end, to turn the trailer around within a circle having a radius equal to the distance from the center of the fixed axle to the opposite end of the trailer. The coupling action is controlled by pushbuttons located in the control lever, the mechanism being actuated





...ity of Tractor-Trailer Units

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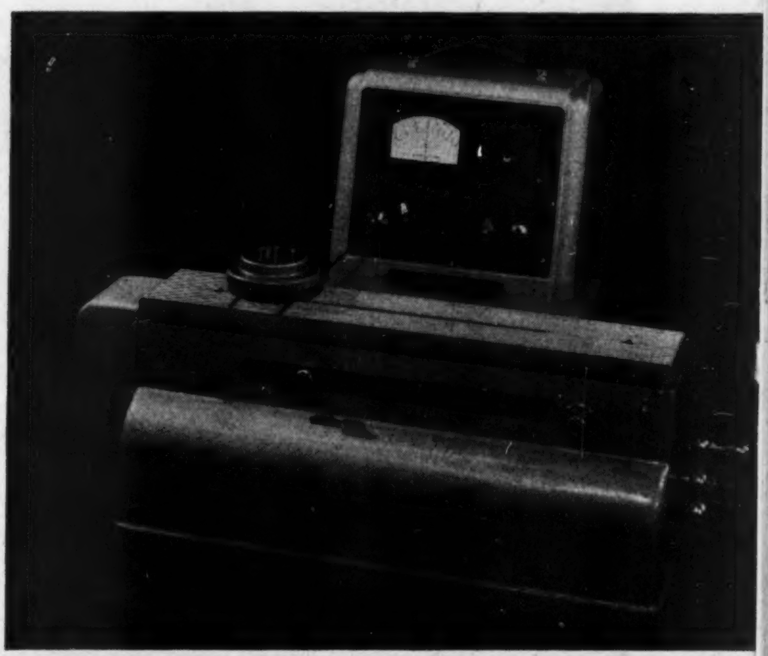
by a hydraulic cylinder. Sequence of operations performed automatically is as follows: (1) the coupling mechanism is elevated through springs attached to the cross-head until the platform contacts the underside of the trailer frame as shown below at left; (2) the platform is pulled toward the tractor, drawing the trailer in closely; simultaneously the towing hooks swing downward to engage the trailer frame thereby coupling the units; and (3) further upward piston movement being prevented because of the completed coupling, the cylinder reaction downward exceeds the force of the four suspension springs, and the pony-wheel carriage is caused to swing upward from the floor against stop lugs. Thereafter, until disengagement is effected, the rear end of the tractor is supported by the trailer. The "Grip-Tow" tractor was designed by engineers at Yale & Towne Mfg. Co., Philadelphia Division.

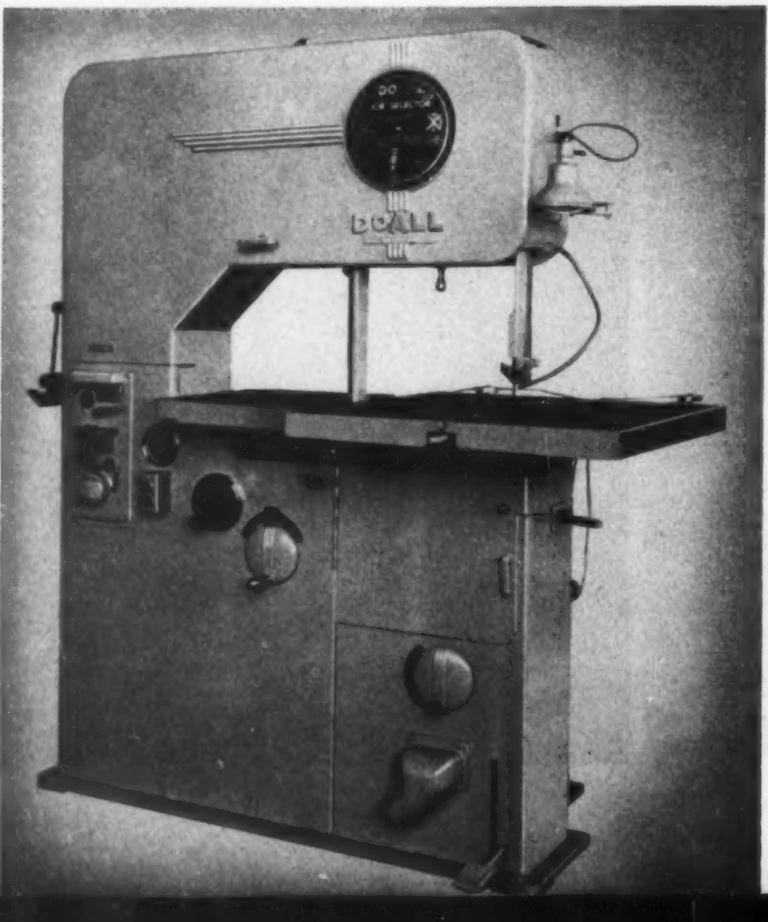


Electronic Gaging Head Has Wide Range

● Remote electronic gage head, right, enables consistently accurate measurement of bores, ranging from 0.240 to 12 inches in diameter and of depth from 1 to 1½ inches from the surface, when fitted with proper gaging arms. A built-in transformer maintains input voltage constant within one per cent even though the line voltage may vary from 95 to 125. This feature prolongs tube life, and the elimination of drift makes unnecessary constant checking of the scale indication with the aid of a master, once the arms have been set for a predetermined size. Standard amplifications range from 300:1 to 10,000:1, and the indicator scale is linear both ways from zero. Made by the Sheffield Corp., the complete unit represents an improvement of the widely known N-6 Interalchek. The basic instrument may be supplemented by console base, illustrated, if ordinary inspection bench mounting is considered unsuitable.

Adjustable Spindle Sander Has Level Worktable

● Spindle assembly is angularly adjustable with respect to the table surface in the design shown. Level working surface thus provided on the Kindt-Collins Co. Master spindle sander and grinder provides greater convenience and better work control. Positioning of the spindle mechanism from vertical to 45-degree position is accomplished by handwheel operation of a worm gear adjustment. A periscope with the eye-piece located in the table surface enables convenient reading of an illuminated protractor scale when establishing the angular setting. Selective oscillating or non-oscillating spindle motion control is provided, and a built-in safety device prevents overspeeding the larger diameter abrasive units.

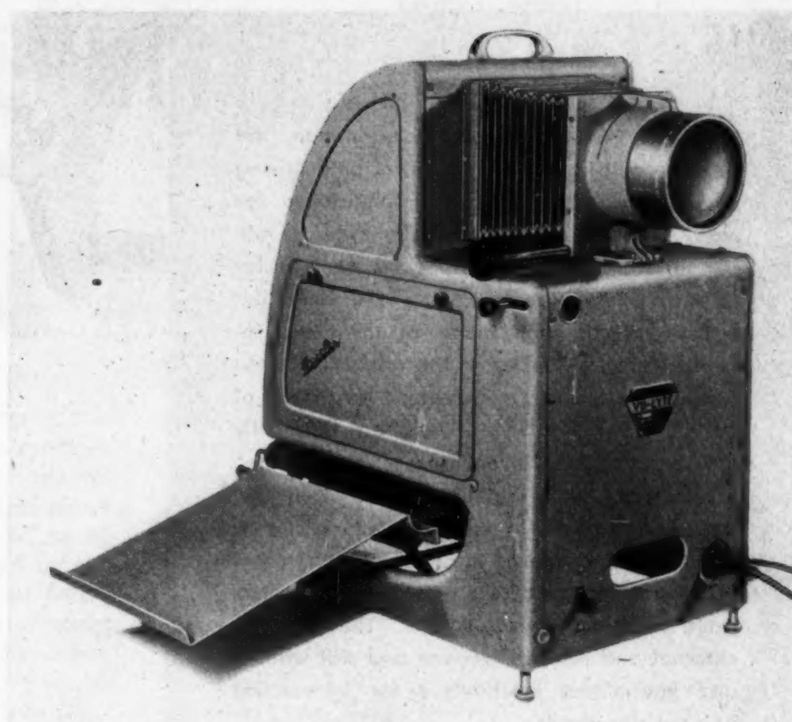


Band Saw Is More Compact

● Incorporated in a relatively light, unit-welded steel frame having a base of 40 by 76 inches, the band saw illustrated has been designed for ordinary band sawing, filing and friction cutting operations requiring a 36-inch throat capacity. Built by the DoALL Co., it has a three-speed transmission providing variable tool velocities ranging from 25 to 6000 fpm for all types of conventional metal sawing, filing or high-speed friction cutting. Normally the band is carried over three wheels but when it becomes shortened it may be used over two wheels on work requiring no more than a 16-inch throat. Equipment built into the machine includes; blade welder with squaring shears, speed indicator, adjustable table light, and automatic hydraulic power feed. Powered by a 3-horsepower motor, the machine has convenient handwheels to adjust feed and tool speed.

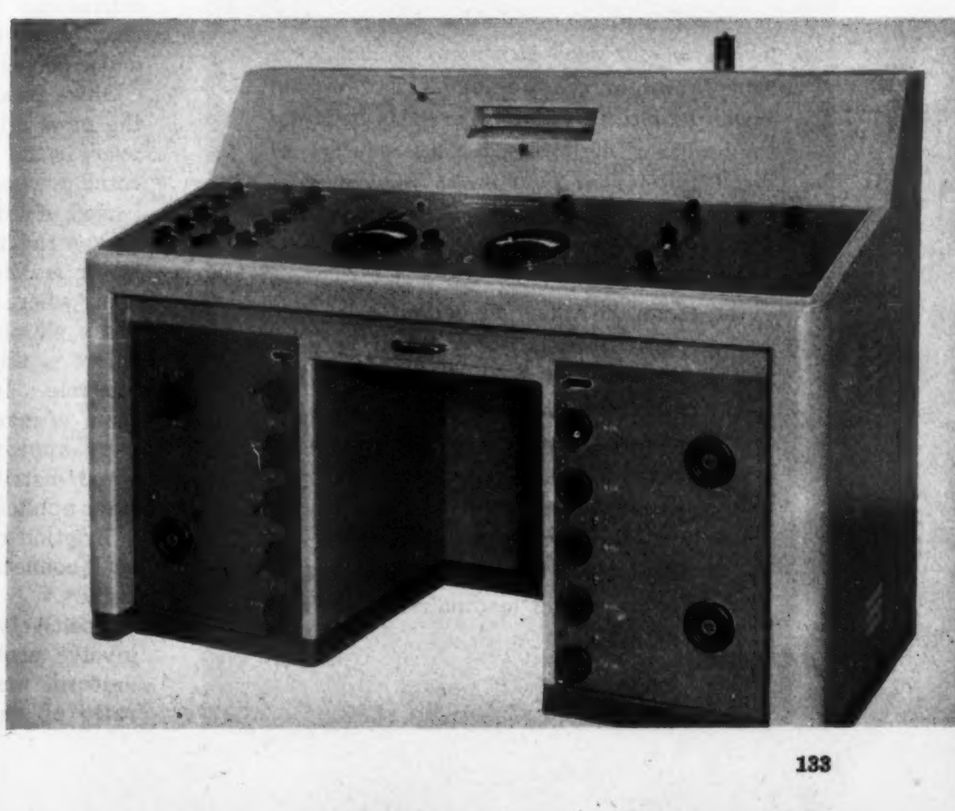
Opaque Objects Vacuum-Held in Projector

• Suction created by a special fan holds copy securely and flatly on the crank-operated endless feed belt of the Vu-Lyte projector shown at right. Continuous copy, such as meter recordings, graphs, charts, etc., or mixed small opaque items may be fed through on the conveyor-type metal platen. Detail of projected images can be clearly pointed out by the operation of a conveniently located knob controlling a unique optical arrangement which superimposes a lighted arrow on the image. These features enable efficient and economical use of the new design because the lecturer also operates the projector, unobstructed view of the screen is possible at all times, object-focus is more uniformly maintained, and it is unnecessary to mount or clamp lightweight copy. Made by Charles Beseler Co., the projector weighs only 33 lb and will accommodate copy size up to 8½ x 11 inches. Spring-loaded legs enable quick adjustment to compensate for uneven mounting surface conditions.



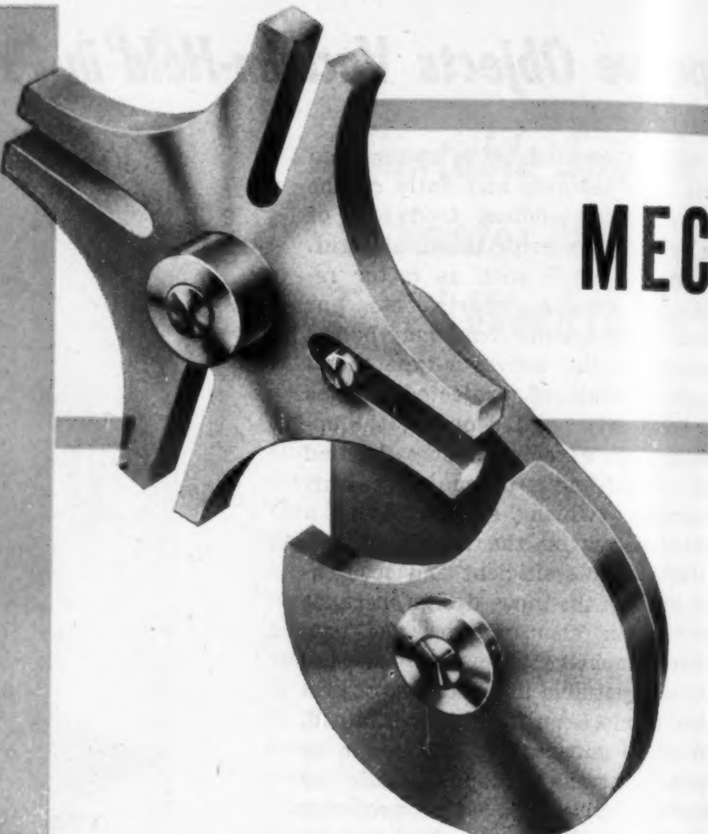
Safety and Convenience Are Designed Into Test Unit

• Testing desk is carefully planned to have all controls within easy reach of a seated operator. Complete enclosure of instruments in the lightweight aluminum desk adds greatly to operator safety and protects the equipment from dust and abuse. Designed by General Electric Co. engineers, this console unit contains all of the major components and auxiliary equipment necessary for making routine d-c magnetization and hysteresis tests and simple flux measurements on magnetic materials and devices. The materials include soft magnetic sheet, strip materials and high-coercive-force compositions such as Alnico, Silmanel and cobalt-platinum magnet alloys. Having a base 30 by 64 inches, the desk has a normal range of current control from zero to 40 amp and operates on any moderately steady 125-volt d-c supply and 115-volt, 60-cycle a-c supply.



MECH

By Otto Lichtwitz
Mechanical Engineer
London, England



In the transmission of rotary motion, the common case is uniform motion of both driving and driven shafts. However, machines for many purposes require a regular cycle of motion and standstills. Various mechanisms for imparting intermittent motion have been devised, and although many of them are ingenious creations, they at the same time often reveal the lack of a systematic treatment of the problems involved. Designers frequently are spending time inventing mechanisms when satisfactory routine solutions exist. It is not, therefore, the aim of this series of articles to compile a selection of mechanisms, but rather to concentrate on a few types which are versatile and generally applicable. These include external and internal Geneva and star wheels, and intermittent mechanisms for intersecting and crossing shafts.

Although graphical methods can be used in laying out the gears in question, and in investigating their kinematic properties, such methods do not offer those possibilities afforded by a mathematical analysis. However, the mathematical treatment is not always simple; functions are in many cases transcendent, and some of the formulas scarcely invite numerical evaluation. Tables are provided, therefore, with small increments so that intermediate values can be interpolated without significant errors. Not only can time be saved by the use of the tables, but the reduction of detail calculations should also prevent overlooking of the woods because of the many trees, and so further the understanding of the essential features.

The scanty literature on gears for intermittent motion is scattered in technical periodicals. Such treatments obviously cannot be uniform, and leave many problems unsolved. Their existence is little known, and they are not generally accessible. It is hoped that the information contained in this and future issues will help to fill a gap in the literature on intermittent gearing, and contribute to a wider field of application of the mechanisms concerned.

ONE of the simplest means for converting continuous motion to intermittent motion is ratchet gears. The motion of ratchet gears is usually derived from a crank or an eccentric, and is thus a modified harmonic motion, with favorable accelerations and retardations. If the motion is derived from cams, equal or still more favorable kinematic properties can be achieved.

Since pawl and wheel are not connected positively, the pawl hits the teeth of the wheel abruptly. Moreover, if the driven shaft is not efficiently braked, the ratchet wheel loses contact with the pawl during the period of intended retardation. The former deficiency makes the ratchet mechanism at least noisy, and the latter makes the amount of rotation unreliable. Except where they serve merely as detents, ratchet gears should, therefore, be restricted to applications where a slight inaccuracy of the movement is permissible. If the motion of ratchet gears is derived from cranks or eccentrics, motion and standstill occupy approximately equal parts of one cycle. This equal distribution may cause a further restriction of their application.

Friction ratchets are quieter, but the lack of a positive connection may result in a still greater inaccuracy.

Positively working gears for intermittent motion involve problems unknown in gears for transmitting uniform motion. Whereas, for uniform motion, the ratio of gearing is specified by the angle through

SMS FOR INTERMITTENT MOTION

PART 1

which the driven shaft rotates during one revolution of the driving shaft, an intermittent motion requires the additional knowledge of distribution of motion and standstill. The actual shape of the teeth of gears for uniform motion does not, as a rule, need to be ascertained by the designer. It is determined by the established system as well as pitch, number of teeth, helix angle, and similar data. In the design of gears for intermittent motion, the main task is the determination of the tooth shapes. Another feature which has no equivalent in gears for uniform motion is that, in addition to the parts for moving, those for locking the driven gear in the periods of standstill also must be designed. The circumferential velocity of uniformly moving gears has little significance at low speeds, and involves at higher speeds only additional considerations in the rating of the gears. On the other hand, varying velocities, and accelerations and retardations of intermittent gears must be carefully investigated, and constitute a further task of the designer.

A well-known means for obtaining positive intermittent motion is the Geneva mechanism. The positive motion of the driven member makes it suitable for exact mechanisms (for example, for presses with dial feed). The best-known application is in moving picture projectors where it gives the intermittent motion of the film. The distribution of motion and standstill is not very flexible.

The star wheel is a kindred mechanism which differs from the Geneva mechanism by the feature that the distribution of motion and standstill can be chosen almost arbitrarily.

The driving member of intermittent gears is usually rotating with constant angular velocity ω, and the angle α through which the driving gear is rotating in

Table 1—Angular Velocities and Their Squares for N rpm

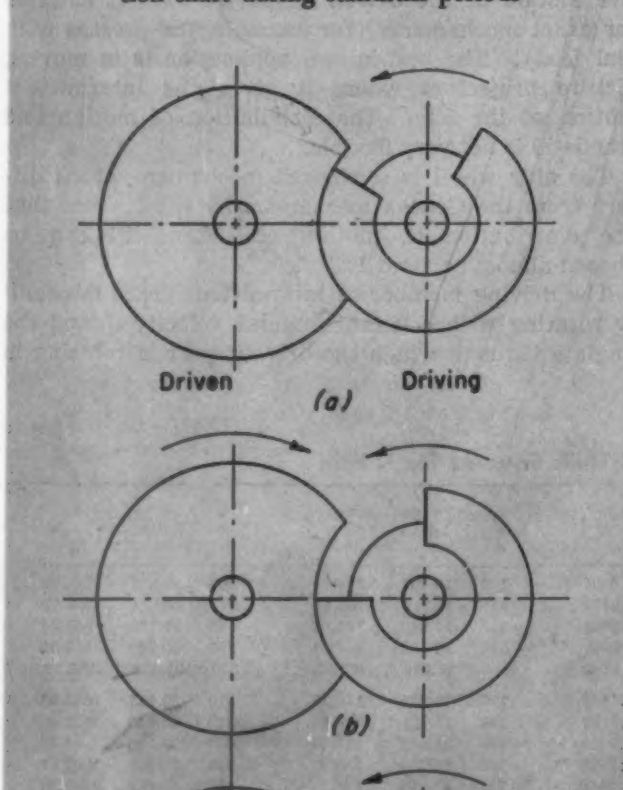
N	$\frac{\pi}{30}N$	$\left(\frac{\pi}{30}N\right)^2$	N	$\frac{\pi}{30}N$	$\left(\frac{\pi}{30}N\right)^2$	N	$\frac{\pi}{30}N$	$\left(\frac{\pi}{30}N\right)^2$	N	$\frac{\pi}{30}N$	$\left(\frac{\pi}{30}N\right)^2$	N	$\frac{\pi}{30}N$	$\left(\frac{\pi}{30}N\right)^2$
1	0.1047	0.0110	26	2.7227	7.4132	52	5.4454	29.6527	105	10.996	120.90	260	27.277	741.32
2	0.2094	0.0439	27	2.8274	7.9943	54	5.6549	31.9771	110	11.519	132.69	270	28.274	799.43
3	0.3142	0.0987	28	2.9322	8.5976	56	5.8643	34.3908	115	12.043	145.03	280	29.322	859.76
4	0.4189	0.1755	29	3.0369	9.2228	58	6.0737	36.8908	120	12.566	157.91	290	30.369	922.28
5	0.5236	0.2742	30	3.1416	9.8696	60	6.2832	39.4782	125	13.090	171.35	300	31.416	986.96
6	0.6283	0.3948	31	3.2463	10.539	62	6.4926	42.1540	130	13.614	185.33	310	32.463	1053.85
7	0.7330	0.5373	32	3.3510	11.229	64	6.7021	44.9180	135	14.137	199.86	320	33.510	1122.95
8	0.8378	0.7018	33	3.4558	11.942	66	6.9115	47.7680	140	14.661	214.94	330	34.558	1194.22
9	0.9425	0.8883	34	3.5605	12.677	68	7.1209	50.7088	145	15.184	230.57	340	35.605	1267.71
10	1.0472	1.0964	35	3.6652	13.434	70	7.3305	53.7350	150	15.708	246.74	350	36.652	1343.37
11	1.1519	1.3269	36	3.7699	14.212	72	7.5398	56.8487	155	16.232	263.46	360	37.699	1421.23
12	1.2566	1.5791	37	3.8746	15.013	74	7.7493	60.0512	160	16.755	280.74	370	38.746	1501.28
13	1.3614	1.8533	38	3.9794	15.835	76	7.9587	63.3400	165	17.279	298.53	380	39.794	1583.50
14	1.4661	2.1494	39	4.0841	16.679	78	8.1681	66.7171	170	17.802	316.93	390	40.841	1667.92
15	1.5708	2.4674	40	4.1888	17.546	80	8.3776	70.1843	175	18.326	335.85	400	41.888	1754.60
16	1.6755	2.8074	41	4.2935	18.434	82	8.5870	73.7367	180	18.850	355.30	410	42.935	1843.39
17	1.7802	3.1693	42	4.3982	19.345	84	8.7965	77.3783	185	19.373	375.32	420	43.982	1934.45
18	1.8850	3.5530	43	4.5029	20.277	86	9.0059	81.1080	190	19.897	395.87	430	45.029	2027.68
19	1.9897	3.9587	44	4.6077	21.231	88	9.2153	84.9220	195	20.420	416.98	440	46.077	2123.05
20	2.0944	4.3865	45	4.7124	22.206	90	9.4248	88.8260	200	20.944	438.65	450	47.124	2220.65
21	2.1991	4.8361	46	4.8171	23.205	92	9.6342	92.8200	210	21.991	483.61	460	48.171	2320.47
22	2.3038	5.3076	47	4.9218	24.225	94	9.8437	99.1560	220	23.038	530.76	470	49.218	2422.50
23	2.4086	5.8013	48	5.0265	25.266	96	10.053	101.065	230	24.086	580.13	480	50.265	2526.61
24	2.5133	6.3166	49	5.1313	26.330	98	10.263	105.322	240	25.133	631.66	490	51.313	2633.01
25	2.6180	6.8540	50	5.2360	27.416	100	10.472	109.64	250	26.180	685.40	500	52.360	2741.56

the time t is ωt. For the sake of simplicity, it will subsequently be assumed that $\omega = 1$. The time t and the angle α are, in that case, numerically equal so that the time can be replaced by the angle covered by the driving gear.

The angular velocity $\omega = 1$ radian per second corresponds to $30/\pi = 9.55$ revolutions per minute. If the number of revolutions per minute is n, the angular velocities must be multiplied by $\pi N/30$. If the rotary motion is converted into a rectilinear motion by rollers or sprocket wheels of diameter d, the linear velocity is obtained by multiplying the angular velocity by $d/2$.

Acceleration, or retardation, of a rotating mass has a tangential and a radial component. The former is of more interest since torque is proportional to it, and since only the tangential component remains if the motion is transformed into rectilinear. In the following considerations, acceleration is always to be understood as the tangential component, for $\omega = 1$.

Fig. 1—Device for locking intermittent-motion shaft during standstill periods



If the number of revolutions per minute is N, the acceleration values thus obtained must be multiplied by $(\pi N/30)^2$. Linear acceleration is obtained from the further multiplication by the radius $d/2$ of the intermittently rotating roller.

Values of $\pi N/30$ and $(\pi N/30)^2$ are contained in TABLE 1. Because acceleration increases with the square of the number of revolutions, considerations of kinematics are indispensable in the design of machines for high speed. The designer should in these cases also endeavor to minimize moments of inertia of driven parts, or of the masses to be accelerated and retarded.

Of the several possibilities for locking the driven shaft during the periods of standstill, one is shown in *Fig.* 1. The locating disk on the driving shaft is a part of a cylinder which fits snugly into a concave recess of a disk on the driven shaft. In the position shown in *Fig.* 1*a*, the disk on the driven shaft is locked since its concave recess is prevented by the locking drum from rotation in either direction. When the locating disk reaches the position shown in *Fig.* 1*b*, the driven shaft is free to rotate clockwise, until the position shown in *Fig.* 1*c* is reached. If the driven shaft has been rotating clockwise, it must come in that position to a standstill, because the driven disk is immediately afterward again prevented from rotating in either direction.

The rotating drum shown in *Fig.* 1 extends over 270 degrees, and the driven shaft is locked during ¾ of one revolution of the driving shaft. The locating drum occupies, generally, the same part of 360 degrees as the period of standstill expressed as a fraction of one cycle.

In actual practice, the means for locating are integral or connected with the driving and driven gears. The locating disk connected with the driven gear has several concave recesses if the driven shaft is rotated, or indexed, a fraction of one revolution during one revolution of the driving shaft.

In the periods of retardation, the driven shaft tends to maintain a higher velocity, and to drive the driving shaft. If there is backlash in the intermittent gears, or in a preceding or following pair of common gears, the change of tooth contact at the start of retardation may cause knocking of the machine. To counteract that influence, backlash should be reduced as far as possible, and it is advisable to provide a brake on the driven shaft. Application of antifriction bearings to the driven shaft would be out of place.

External Geneva Mechanism: The Geneva wheel has in its most common form four arms, *Figs.* 2 and 3, and its resemblance to the ensign of the Order of the Knights of Malta accounts for the alternative name, Maltese Cross.

A mechanism with five stations is shown in *Fig.* 4 in two different positions. The driving gear comprises a driving roller and a locking drum. In the position shown in *Fig.* 4*a*, the roller is about to enter one of the slots of the driven gear. At this moment the locking drum has reached a position in which the driven gear can be rotated in the indicated direction, and the motion of the driven gear lasts until

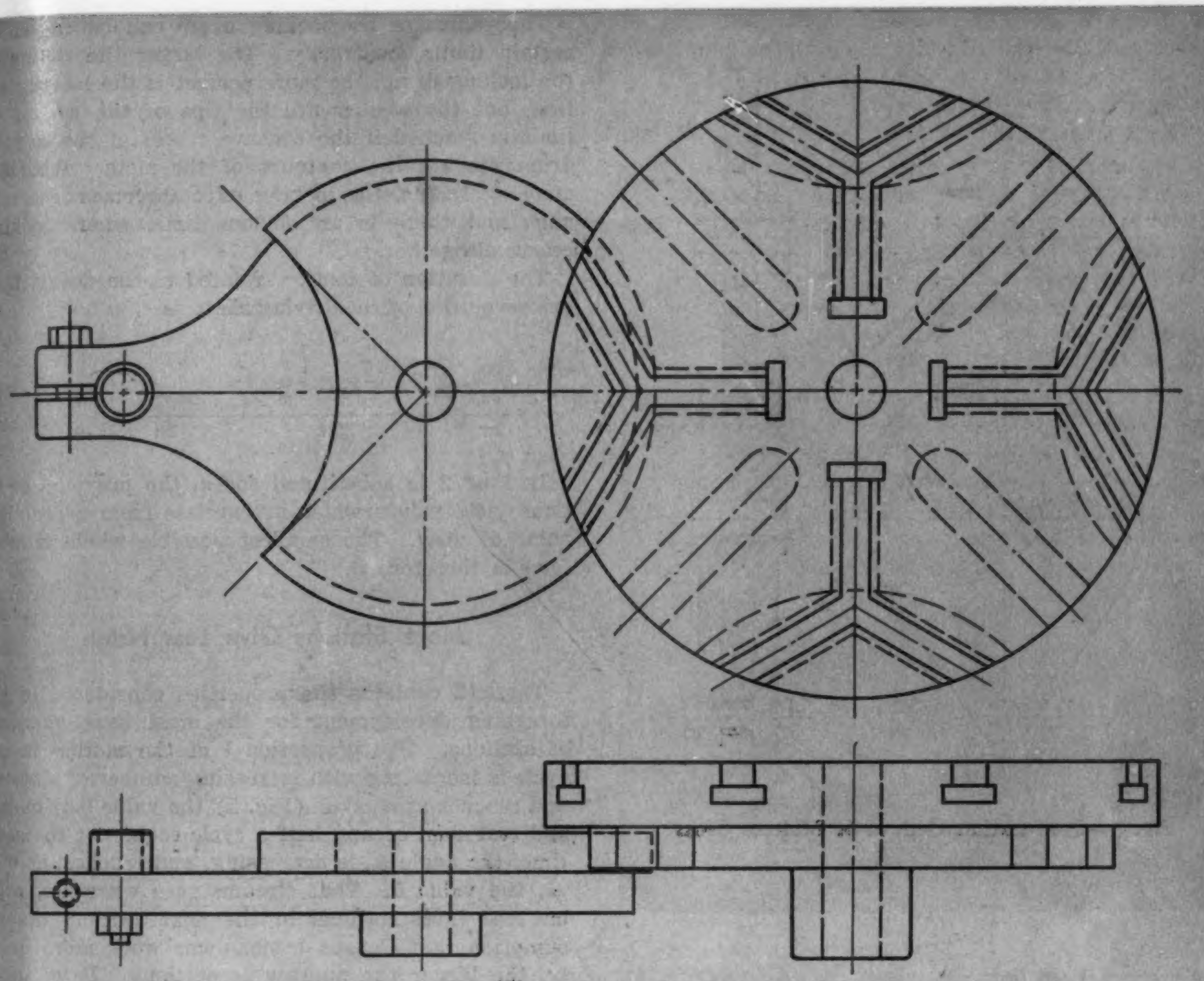


Fig. 2—Four-station Geneva with the driven gear serving as a machine table

the driving roller reaches the position indicated by dotted lines. The locking drum then prevents a movement of the driven gear, until the roller re-enters the next slot.

GEOMETRY: All figures so far mentioned show Geneva wheels where, in the position of standstill, the straight radial center lines of the slots are tangents to the circular path of the center of the driving roller. With this configuration, the driven gear commences and terminates the motion without shock. Although this feature is not absolutely necessary, only gears of this kind will be considered because they have definite geometrical relations.

The Geneva wheel shown in ***Fig.*** 4 may be considered as having generally n equally spaced slots. ***Fig.*** *4a* shows the gears in the position when the driving roller is entering a slot. The angle β_0 between the center line of the slot and the line connecting the centers of driving and driven gears is, expressed in radians,

$$\beta_0 = \frac{\pi}{n} \qquad (1)$$

If this or any other angle is to be expressed in degrees, π must be replaced by 180 deg, or the arc must be multiplied by $180/\pi$.

The corresponding angle α_0 which the driving roller is short of the central position is

$$\alpha_0 = \frac{\pi}{2} - \beta_0 = \frac{\pi}{2} - \frac{\pi}{n} = \frac{\pi}{2}\,\frac{n-2}{n} \qquad (2)$$

During n revolutions of the driving gear, the driven gear makes one revolution, so that the ratio of gearing is in a certain sense n. It is, however, more expedient to consider only the period of motion, or to correlate the angles α_0 and β_0, and to call $\epsilon = \alpha_0/\beta_0$ the ratio of gearing.

$$\epsilon = \frac{\alpha_0}{\beta_0} = \frac{\dfrac{\pi}{2}\,\dfrac{n-2}{n}}{\dfrac{\pi}{n}} = \frac{n-2}{2} \qquad (3)$$

If the center distance of driving and driven gears is a, the radii of driving and driven gear are

$$r_1 = a \sin \beta_0 \qquad (4)$$

$$r_2 = a \cos \beta_0 \qquad (5)$$

and their ratio is

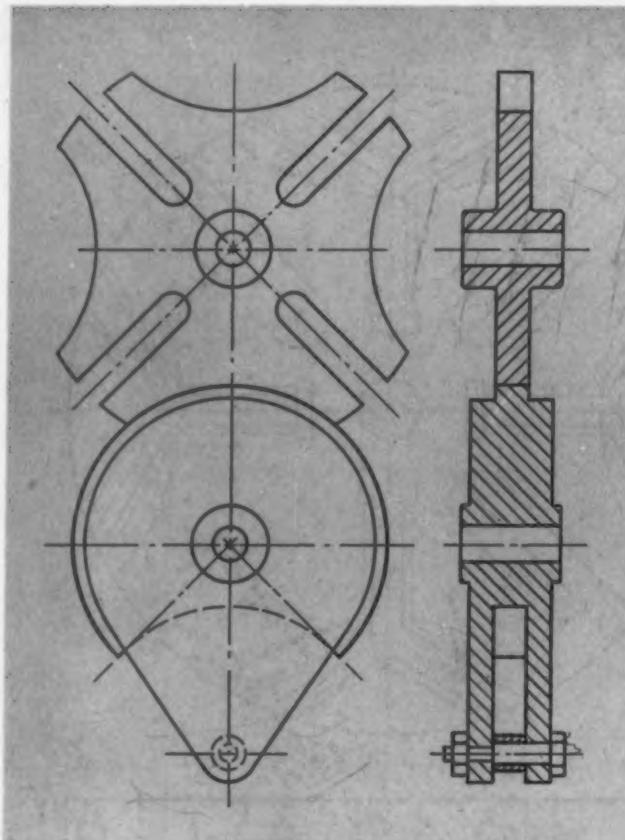


Fig. 3—Four-station Geneva or Maltese Cross

$$\mu = \frac{r_2}{r_1} = \cot \beta_0 \quad \ldots\ldots (6)$$

Equations 3 and 6 show that ε and μ are, in contrast to the rules of common gearing, not identical (except in the case of $n = 4$).

The distance s of the inner end of the slot from the center of the driven gear is

$$s \leqq a - r_1 = a\ (1 - \sin \beta_0) \quad \ldots\ldots (7)$$

The angle over which the locking drum extends is

$$\gamma = 2(\pi - \alpha_0) = 2\left(\pi - \frac{\pi}{2} + \frac{\pi}{n}\right)$$

$$= \frac{\pi}{n}\ (n + 2) \quad \ldots\ldots (8)$$

The radius of the locking drum can be chosen in certain limits arbitrarily. The larger the radius of the locking drum, the more perfect is the locking action, but the weaker are the tips of the wheel. A limit is reached if the concave recess of the locking drum reaches the contours of the slots. With decreasing radius, the locking effect becomes less reliable, and there is an obvious limit where locking ceases altogether.

The duration of motion, related to the duration of one revolution of the driving shaft, is

$$\nu = \frac{2\alpha_0}{2\pi} = \frac{2\left(\frac{\pi}{2} - \frac{\pi}{n}\right)}{2\pi} = \frac{n-2}{2n} = \frac{\varepsilon}{n} \quad \ldots (9)$$

If 1 or 2 is substituted for n, the previous equations yield values which are useless from a practical point of view. The smallest possible whole number for n is, therefore, 3.

More Stations Give Less Noise

TABLE 2 contains the properties considered in the foregoing development for the most usual numbers of stations. The proportion ν of the motion in one cycle is increasing with increasing number of stations, and reaches at $n = \infty$ (*Fig.* 5) the value 0.5; motion and rest then occupy half a cycle each. At the same time, the angle β_0 is decreasing, and reaches, at $n = \infty$, the value 0. That circumstance warrants, without the investigations in the next section, the assumption that Geneva mechanisms work more quietly, the larger the number of stations. It is, therefore, advantageous to make that number higher than absolutely necessary. Some presses with dial feed have more stations than the process actually requires, in spite of higher costs for tooling. However, it must be ascertained in such cases whether a reduction of the period of standstill is feasible.

KINEMATICS: In *Fig.* 4*b* the gear is shown in a position during the period of motion, when the driving gear angle is α, and the driven gear angle β beyond the central position.

The distance of the driving roller from the center of the driving gear is $AC = r_1 = a \sin \beta_0$ (Equation 4). The distance $BC = \rho$ (roller to center of driven gear) is

Table 2—External Geneva Mechanisms

n	β_0	α_0	ε	$\frac{r_1}{a}$	$\frac{r_2}{a}$	μ	$\frac{s}{a}$	γ	ν	$\left(\frac{d\beta}{d\alpha}\right)_0$	$\left(\frac{d^2\beta}{d\alpha^2}\right)_{-\alpha_0}$	α_{max}	$\left(\frac{d^2\beta}{d\alpha^2}\right)_{max}$	$\left(\frac{d^3\beta}{d\alpha^3}\right)_0$	m_{max}
Stations	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6	Eq. 7	Eq. 8	Eq. 9	Eq. 12	Eq. 14	Eq. 16	Eq. 17	Eq. 18	Eq. 19
3	60°	30°	0.5	0.8660	0.5000	0.5774	0.13397	300°	0.16667	6.46	1.732	4°46′	31.44	−672.0	6
4	45°	45°	1	0.7071	0.7071	1.0000	0.2929	270°	0.2500	2.41	1.000	11°24′	5.400	−48.04	4
5	36°	54°	1.5	0.5878	0.8090	1.3764	0.4122	252°	0.3000	1.43	0.7265	17°34′	2.299	−13.32	3
6	30°	60°	2	0.5000	0.8660	1.7320	0.5000	240°	0.3333	1.00	0.5774	22°54′	1.350	−6.000	3
7	25°43′	64°17′	2.5	0.4339	0.9009	2.0765	0.5661	231°26′	0.3571	0.766	0.4816	27°33′	0.9284	−3.429	2
8	22°30′	67°30′	3	0.3827	0.9239	2.4142	0.6173	225°	0.3750	0.620	0.4142	31°38′	0.6995	−2.249	2
9	20°	70°	3.5	0.3420	0.9397	2.7475	0.6580	220°	0.3889	0.520	0.3640	35°16′	0.5591	−1.611	2
10	18°	72°	4	0.3090	0.9511	3.0777	0.6910	216°	0.4000	0.447	0.3249	38°30′	0.4648	−1.236	2
∞	0°	90°	∞	0	1	∞	1	180°	0.5000	0	0	90°	0	0	2

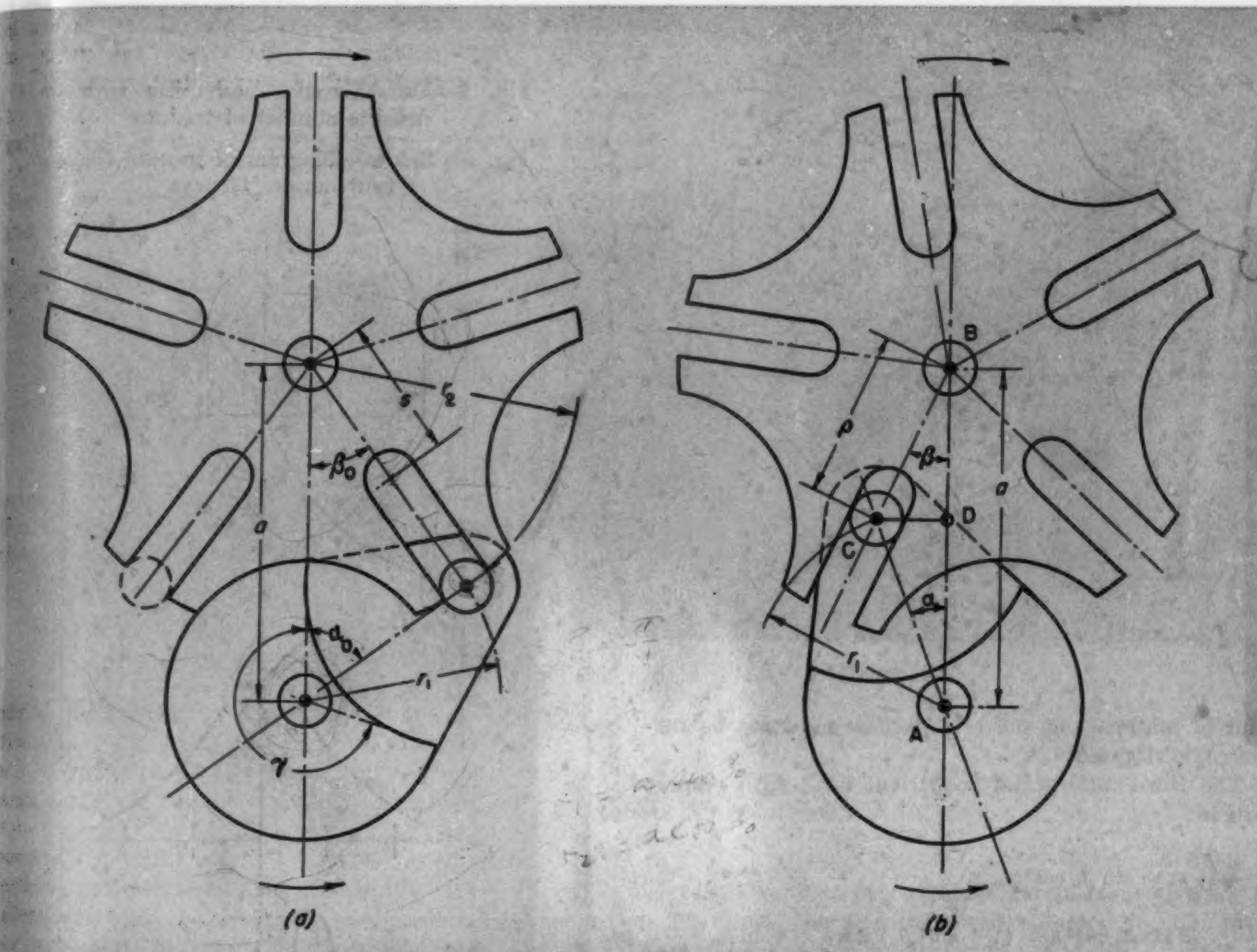


Fig. 4—Geneva mechanism in the position at the commencement of motion, *a*, and in a general position during the period of motion, *b*

$$\rho = \sqrt{a^2 + r_1{}^2 - 2ar_1 \cos \alpha}$$
$$= a\sqrt{1 + \sin^2 \beta_0 - 2 \sin \beta_0 \cos \alpha}$$

Because the distance CD $= r_1 \sin \alpha = \rho \sin \beta$,

$$\sin \beta = \frac{r_1}{\rho} \sin \alpha = \frac{\sin \beta_0 \sin \alpha}{\sqrt{1 + \sin^2 \beta_0 - 2 \sin \beta_0 \cos \alpha}}$$

Therefore,

$$\beta = \sin^{-1} \frac{\sin \beta_0 \sin \alpha}{\sqrt{1 + \sin^2 \beta_0 - 2 \sin \beta_0 \cos \alpha}} \quad \text{(10)}$$

If the driving gear is rotating with unit angular velocity, so that the time t can be replaced by the angle α, the angular velocity of the driven gear is obtained by differentiating β with respect to α:

$$\frac{d\beta}{d\alpha} = \frac{\sin \beta_0 (\cos \alpha - \sin \beta_0)}{1 + \sin^2 \beta_0 - 2 \sin \beta_0 \cos \alpha} \quad \text{(11)}$$

It is obvious from *Fig.* 4*b* that the shortest distance ρ pertains to the central position ($\alpha = 0$), and that the angular velocity has there a maximum, namely

$$\left(\frac{d\beta}{d\alpha}\right)_0 = \frac{\sin \beta_0}{1 - \sin \beta_0} = \frac{\sin \beta_0}{2 \sin^2 \left(\frac{\pi}{4} - \frac{\beta_0}{2}\right)} \quad \text{(12)}$$

The first expression in Equation 12 can readily be found directly from *Fig.* 4*b*; the second expression is more convenient for logarithmic evaluation.

Differentiating Equation 11 with respect to α leads to the angular acceleration of the driven gear.

again + α

$$\frac{d^2\beta}{d\alpha^2} = -\frac{\sin \beta_0 \cos^2 \beta_0 \sin \alpha}{(1 + \sin^2 \beta_0 - 2 \sin \beta_0 \cos \alpha)^2} \quad \text{(13)}$$

Before the central position is reached ($\alpha < 0$), the value $d^2\beta/d\alpha^2$ is greater than 0, or the driven gear is accelerated. In the central position ($\alpha = 0$), $d^2\beta/d\alpha^2 = 0$. After the central position has been reached ($\alpha > 0$), $d^2\beta/d\alpha^2 < 0$, or the driven gear is retarded.

The acceleration at the start of motion is obtained by substituting $\alpha = -\alpha_0 = \beta_0 - \frac{1}{2}\pi$ in Equation 13.

$$\left(\frac{d^2\beta}{d\alpha^2}\right)_{-\alpha_0} = \tan \beta_0 \quad \text{(14)}$$

Because of the symmetry of the mechanism, the same value will be found for the retardation at the

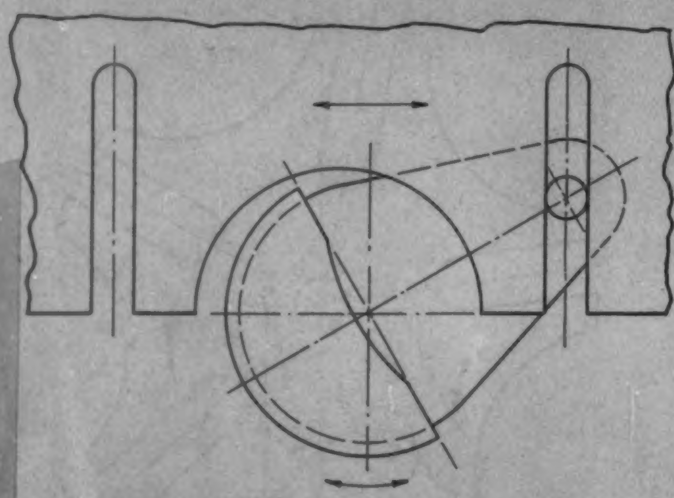
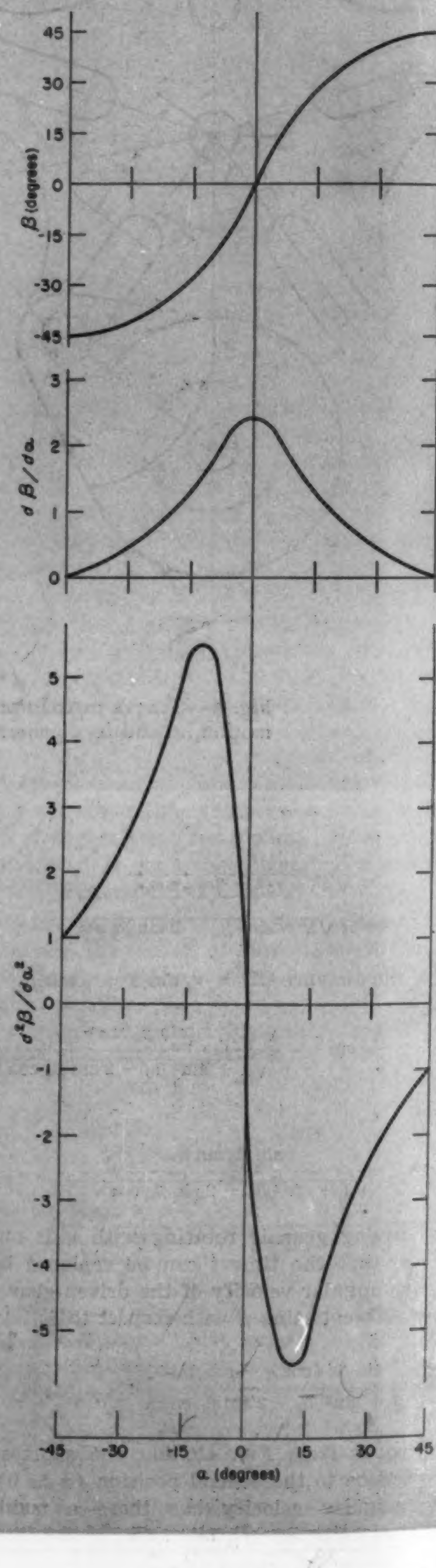


Fig. 5—Left—Geneva mechanism with indefinite number of stations

Fig. 6—Below—Diagram of motion for the four-station Geneva



end of motion, and the retardations need not be further investigated.

The third differential coefficient of β with respect to α is

$$\frac{d^3\beta}{d\alpha^3} = -\sin\beta_0\cos^2\beta_0 \times$$

$$\frac{2\sin\beta_0\cos^2\alpha + (1+\sin^2\beta_0)\cos\alpha - 4\sin\beta_0}{(1+\sin^2\beta_0 - 2\sin\beta_0\cos\alpha)^3} \quad (15)$$

An extreme value of the angular acceleration, and that a maximum, pertains to the position where $d^3\beta/d\alpha^3 = 0$, or where

$$2\sin\beta_0\cos^2\alpha + (1+\sin^2\beta_0)\cos\alpha - 4\sin\beta_0 = 0$$

The solution is

$$\cos\alpha = -\frac{1+\sin^2\beta_0}{4\sin\beta_0} \pm \sqrt{\left(\frac{1+\sin^2\beta_0}{4\sin\beta_0}\right)^2 + 2}$$

As the value under the square root radical is larger than 1, only the plus sign is to be used, so that

$$\alpha_{max} = \cos^{-1}\left[-\frac{1+\sin^2\beta_0}{4\sin\beta_0} + \sqrt{\left(\frac{1+\sin^2\beta_0}{4\sin\beta_0}\right)^2 + 2}\right] \quad (16)$$

By substituting $\alpha = \alpha_{max}$ in Equation 13, the maximum of the angular acceleration is obtained

$$\left(\frac{d^2\beta}{d\alpha^2}\right)_{max} = -\frac{\sin\beta_0\cos^2\beta_0\sin\alpha_{max}}{(1+\sin^2\beta_0 - 2\sin\beta_0\cos\alpha_{max})^2} \quad (17)$$

For the Maltese Cross with four stations, *Fig.* 6 shows β, $d\beta/d\alpha$, and $d^2\beta/d\alpha^2$ plotted against α, of which $d^2\beta/d\alpha^2$ is the most interesting. The acceleration starts at -45 deg suddenly with a definite amount, rises to a maximum at $\alpha = -11$ deg, 24 min, and falls rather sharply to zero at $\alpha = 0$. The right hand side of the graph shows an analogous

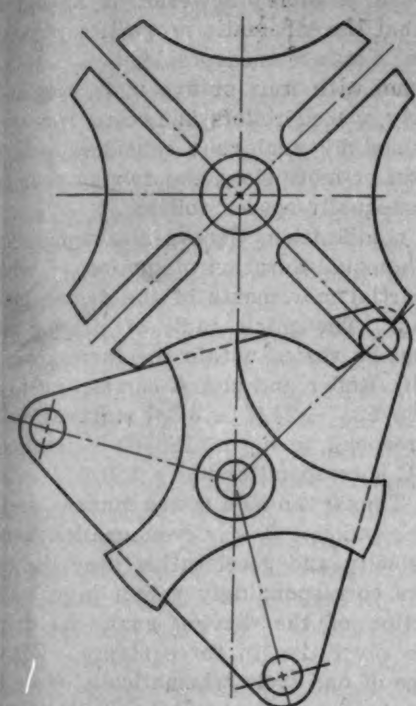


Fig. 7 — Left — Geneva mechanism with four regularly distributed slots and three regularly distributed rollers

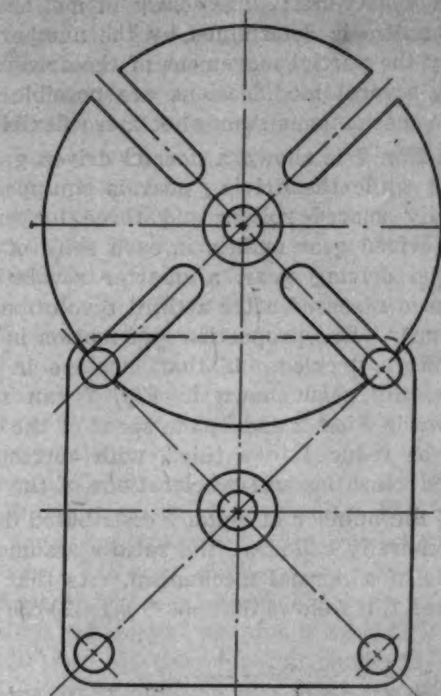


Fig. 8—Right—Geneva mechanism with four regularly distributed slots and four regularly distributed rollers

course of the retardation for the Maltese Cross.

A measure for the steepness with which the curve $d^2\beta/d\alpha^2$ passes through the origin of the graph, or a measure for the rate at which the acceleration changes into retardation, is obtained by substituting $\alpha = 0$ in Equation 15.

$$\left(\frac{d^3\beta}{d\alpha^3}\right)_0 = -\frac{\sin\beta_0\cos^2\beta_0}{(1-\sin\beta_0)^4}$$

$$= -\frac{\sin\beta_0\cos^2\beta_0}{16\sin^8\left(\frac{\pi}{4}-\frac{\beta_0}{2}\right)} \qquad (18)$$

The minus sign denotes that the acceleration decreases, near the central position, with increasing angle α, and only the absolute value is of interest.

TABLE 2 contains, besides the values discussed in the previous section, $(d\beta/d\alpha)_0$, $(d^2\beta/d\alpha^2)_{-\alpha_0}$, α_{max}, $(d^2\beta/d\alpha^2)_{max}$, and $(d^3\beta/d\alpha^3)_0$.

EXAMPLE 1. To investigate the kinematic properties of a Geneva mechanism with four stations which is driving a feed roller of 5.093-inches diameter to obtain per revolution the amount of feed 5.093 $\pi/4$ = 4 inches. N = 50 rpm.

For $\omega = 1$, the maximum angular velocity is, according to TABLE 2, 2.41 radians per second. For N = 50, it is (from TABLE 1) 5.2360 (2.41) = 12.62 radians per second, and the maximum linear velocity is ½(5.093) (12.62) = 32.14 inches per second.

For $\omega = 1$, the angular acceleration at the start of motion is 1; at α_{max} = −11 deg, 24 min, it is 5.41 radians per second squared (TABLE 2). For N = 50, these values must be multiplied by 27.416 (TABLE 1), so that they are 27.416 (1) = 27.416, and 27.416 (5.4) = 148.32 radians per second squared, respectively.

The linear accelerations are obtained by the further multiplication by ½ (5.093). At the start, it is 69.815 inches per second squared, and at the maximum, it is 377.697 inches per second squared. The latter amount, or 31.475 feet per second squared, is slightly less than the acceleration due to gravity of the earth.

EXAMPLE 2: TABLE 2 reveals that the kinematic properties are more favorable the larger the number of stations. To realize the influence of n, it may be assumed that, in Example 1, n is reduced to 3.

As the driven shaft makes $\frac{1}{3}$, instead of $\frac{1}{4}$ revolution per cycle, the diameter of the feed roller is reduced to $\frac{3}{4}$ (5.093) = 3.820 inches, to obtain the same amount of feed.

The maximum angular velocity is increased to the 6.46/2.41 = 2.68 fold amount.

The maximum linear velocity is more than doubled, since $\frac{3}{4}$ (6.46/2.41) = 2.01.

The angular acceleration at the start of motion is 1.732/1 = 1.732 fold, and the linear acceleration at the start is $\frac{3}{4}$ (1.732) = 1.30 fold.

The maximum angular acceleration is 31.44/5.410 = 5.81 fold, and the maximum linear acceleration is $\frac{3}{4}$ (31.44/5.410) = 4.36 fold.

The rate of change from angular acceleration to retardation is 672.0/48.04 = 13.99 fold, and that of the linear acceleration to retardation is $\frac{3}{4}$ (672.0/48.04) = 10.49 fold. Example 2 shows that the step from four to three stations is accompanied by a considerable deterioration of the kinematic properties. Since even the Geneva mechanism with four stations is not to be regarded as kinematically favorable,

mechanisms with three stations are best avoided.

MODIFICATIONS: The course of motion of a Geneva mechanism is determined by the number of stations, or by the partial movement of the driven gear. However, several modifications are possible which make these mechanisms somewhat more flexible.

In *Fig.* 7 is shown a normal driven gear with four slots, while the driving gear is equipped with three equally spaced rollers and three locking segments. The driven gear makes, in each third of a revolution of the driving gear, a quarter revolution, and the cycle is repeated after a third revolution of the driving gear. The proportion ν of motion in one cycle is, therefore, trebled. If that increase in ν is permissible, the gear shown in *Fig.* 7 can replace those shown in *Figs.* 2 and 3; the speed of the driving shaft can be reduced to a third, with correspondingly reduced velocities and accelerations of the driven parts.

If the number of equally distributed driving rollers is generally called m, the ratio ν assumes the m-fold value of a normal mechanism. As that ratio cannot exceed 1, it follows that $m\nu = m(n\text{-}2)/2n \leqq 1$, or

$$m \leqq \frac{2n}{n-2} = 2 + \frac{4}{n-2} \qquad \text{(19)}$$

As m must be an integer, the nearest lower whole number to the result of Equation 19 is indicated in TABLE 2 as m_{max}. It is possible that $m < 2$ rollers if the driven gear has six or less stations.

If there are, for example, four stations, TABLE 2 indicates $m_{max} = 4$, which is exactly the value of the right-hand side of Equation 19. In this case, *Fig.* 8, there are no standstills. At the moment when a roller is leaving a slot, another roller is entering the next slot. The driven gear is regularly slowed down to zero velocity, without remaining at rest, and no locking devices are required.

Spacing Can Be Irregular

The rollers of the driving gear need not be equally spaced. In *Fig.* 9, there are three rollers in the driving gear and four slots in the driven gear. Each movement occupies 90 deg of the driving gear (determined by $n = 4$), and the driven gear is always indexed 90 deg. There is a standstill of 15 deg between the action of rollers A and B, a standstill of 30 deg between the action of rollers B and C, and a standstill of 45 deg between the action of rollers C and A. The duration of the individual standstills can be chosen arbitrarily (also zero), as long as their sum is, in the case under consideration, $360 - 3\,(90) = 90$ deg; for n stations, and m driving rollers, the sum is $180\,[2 - m(n-2/n)]$ deg. The number of irregularly distributed rollers cannot exceed that found in Equation 19 for regularly distributed ones.

The application of Geneva mechanisms with regular driven gear, but irregularly arranged driving rollers, is restricted.

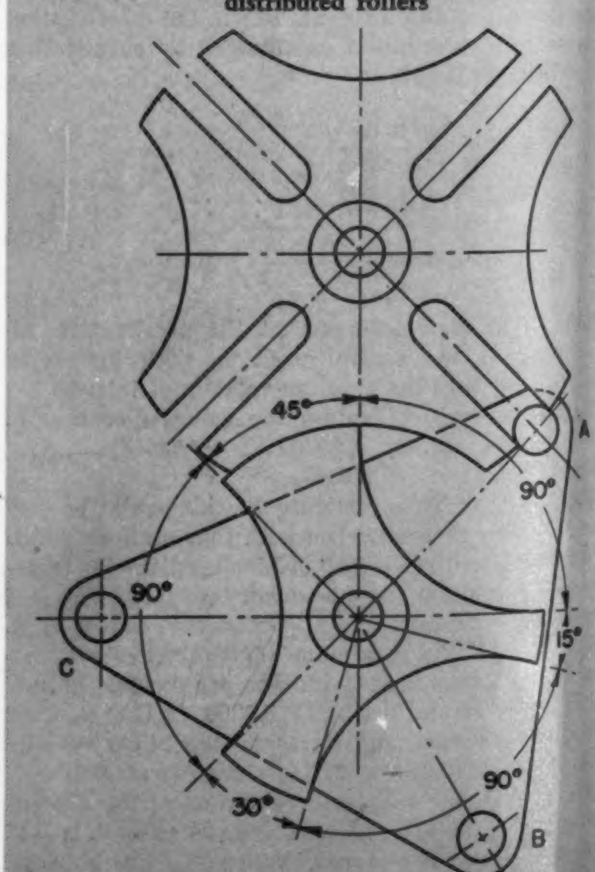
In the case of three slots in the driven gear, Equation 19 indicates $m \leqq 6$ equally spaced rollers. The case of $m = 1$ pertains to the normal Geneva mechanism, and a driving gear with six rollers does not permit an irregularity as it leaves no standstills. Driving gears with two, three, four, or five irregularly spaced rollers are possible; however, it should be borne in mind that the kinematic properties of mechanisms with three slots are unfavorable.

For mechanisms with four or five slots, the number of irregularly spaced rollers is two or three, respectively, obtained by analogous considerations.

If there are six or more slots, the driving gear can have only two unequally spaced rollers.

As a further modification, Geneva mechanisms can be laid out for unequal duration of motion, in which case also the partial movements of the driven member are varying. The pitch radii of driving and driven gear must be varied within the same gear, as shown in *Fig.* 10. Roller and slot A correspond to $n_A = 180/\beta_0 = 180/52\frac{1}{2} = 24/7 = 3\ 3/7$ stations; roller and slot B correspond to $n_B = 186/60 =$ stations; roller and slot C correspond to $n_C = 180/67\frac{1}{2} = 8/3 = 2\frac{2}{3}$ stations. Thus n can be a mixed number, and in the case of roller and slot C, n is even smaller than 3. The angular velocity and acceleration near the central position are correspondingly rather high. During one revolution of the driving gear, the driven gear makes one revolution in three stages. *Fig.* 11 shows the course of one cycle schematically, since the lines of motion actually are not straight.

Fig. 9—Geneva mechanism with four regularly distributed slots and three irregularly distributed rollers



In *Fig.* 12 is shown an irregular Geneva mechanism with four slots and two rollers. During two revolutions of the driving gear, the driven gear makes one revolution in four stages. Although the slots include equal angles of 90 deg, the partial movements of the driven gear are alternately 2 ($37\frac{1}{2}$) = 75 deg, and 2 ($52\frac{1}{2}$) = 105 deg. The corresponding angles of the driving gear are 105 and 75 deg, respectively, separated by standstills of 120 and 60 deg.

The application of Geneva mechanisms with varying partial movements is restricted, similarly as for merely irregularly spaced driving rollers.

In the case of three slots in the driven gear, only one, three, six, etc., rollers are to be considered. One roller pertains to the normal Geneva mechanism. If there are three rollers, the angle $2\beta_0$ of the driven gear corresponds, for any partial movement, to the angle $2\,\alpha_0 = 180 - 2\,\beta_0$ (Equation 2) of the driving gear. Whatever the individual three angles β_0 are, the sum of all angles $2\,\beta_0$ is 360 deg, and the sum of the three angles $2\,\alpha_0$ is $3\ (180) - 360 = 180$ deg. The standstills occupy the remaining 180 deg which need not necessarily be divided into three equal parts. In *Fig.* 10 they are equal. If there are six rollers, the driven gear makes two revolutions per revolution of the driving gear. The sum of six angles $2\,\beta_0$ is 720 deg; the sum of the six angles $2\,\alpha_0$ is $6\ (180) - 720 = 360$ deg, so that there cannot be standstills. If more than six rollers were contemplated, the sum of the angles $2\,\alpha_0$ would exceed 360 deg. There remain thus only the cases of three and six rollers.

In the case of four slots, two, four, etc., rollers may be considered. One revolution of the driving gear with two rollers corresponds to half a revolution of the driven gear. The sum of two angles $2\,\beta_0$, corresponding to one revolution of the driving gear, is 180 deg; the sum of the two angles $2\,\alpha_0$ is $2\ (180) - 180 = 180$ deg, and the remaining 180 deg can be divided into two standstills. If a driving gear with four rollers is considered, the sum of the four angles $2\,\beta_0$ is 360 deg, and the sum of the four angles $2\,\alpha_0$ is $4\ (180) - 360 = 360$ deg. A mechanism of this kind can only be applied if there are no standstills. More than four rollers are not possible.

With five slots, the sum of five angles $2\,\alpha_0$ is $5\ (180) - 360 = 540$ deg. As the prime number 5 does not permit less than five rollers, irregular mechanisms are not possible. The same applies to any higher uneven number, whether it is prime or not.

With six slots, the sum of six angles $2\,\alpha_0$ is $6\ (180) - 360 = 720$ deg. If there are no standstills, one cycle comprises two revolutions of a driving gear with three rollers. If standstills are required, there remains only the case of two rollers. It will be found by similar considerations that, for higher even numbers of slots, Geneva mechanisms with unequal duration of the partial movements of the driven gear are only possible with two rollers.

In the design of Geneva mechanisms such as shown in *Figs.* 10 and 12, TABLE 2 is not sufficient if n is a mixed number. The relevant dimensions can be found graphically, or by means of calculations.

EXAMPLE 3: To design a mechanism as shown in *Fig.* 12, for a center distance $a = 10$ inches.

The roller A and the two slots A correspond to $n_A = 180/\beta_0 = 180/52\frac{1}{2} = 24/7 = 3\ 3/7$ stations, not contained in TABLE 2.

The radii of driving and driven gears are $r_{1A} = a$

Fig. 10—Geneva mechanism with three irregularly distributed slots and three irregularly distributed rollers

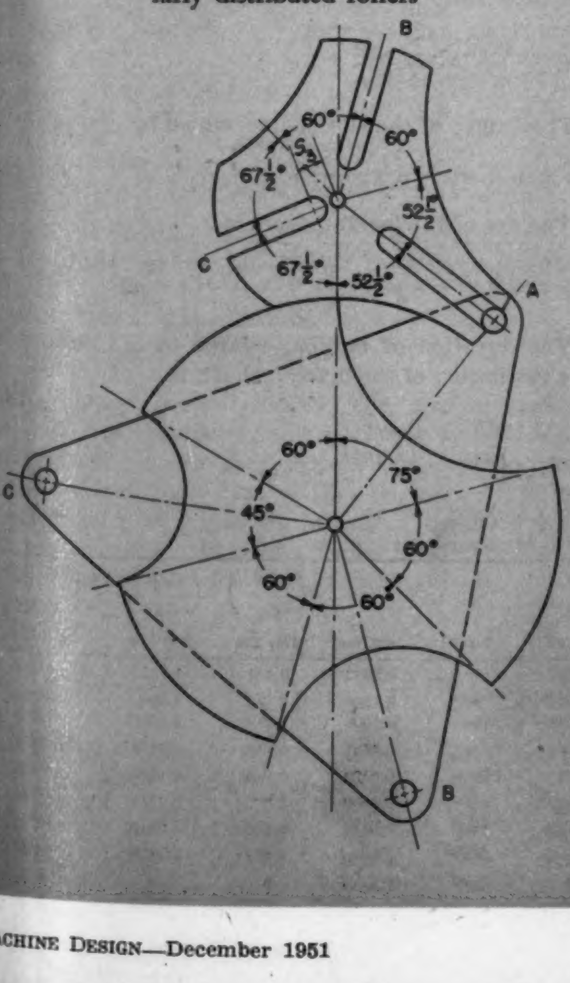
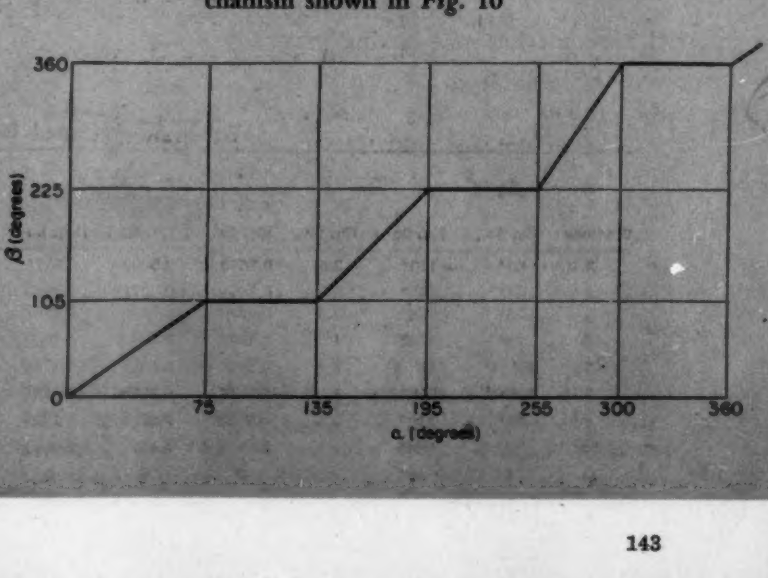


Fig. 11—Displacement diagram of the mechanism shown in *Fig.* 10



$\sin \beta_0 = 10 \sin 52\frac{1}{2} = 7.934$ inches and $r_{2A} = a \cos \beta_0 = 10 \cos 52\frac{1}{2} = 6.088$ inches. The distance between the center of the driven gear and the inner end of slot A must be smaller than $s_A = a\,(1 - \sin \beta_0) = 10\,(1 - \sin 52\frac{1}{2}) = 2.066$ inches.

Similarly, the roller B and the two slots B correspond to $n_B = 180/37\frac{1}{2} = 24/5 = 4\ 4/5$ stations. Then $r_{1B} = 10 \sin 37\frac{1}{2} = 6.088$ inches, $r_{2B} = 10 \cos 37\frac{1}{2} = 7.934$ inches and $s_B = 10\,(1 - \sin 37\frac{1}{2}) = 3.912$ inches.

Irregular Geneva mechanisms leave a certain freedom in designing. But as a rule, the partial movements of the driven gears should not differ greatly from each other, because the means for locking otherwise assume unfavorable shapes, or even become impossible.

Design for Production: The pins for the driving rollers may be secured on one end, *Fig.* 2, or on both ends, *Fig.* 3, to the body of the driving gear. The rollers are preferably hardened steel.

To reduce the friction between locking drum and locking shoes, it is advisable to make one member steel and one cast iron; with a large driven gear, the latter is preferably the cast-iron one. That would be the case, for example, on dial-feed presses with a vertical shaft (similar to *Fig.* 2), where the lower side of the casting forms the Geneva wheel, and the upper surface is provided with T-slots for clamping down the tools.

The angle during which the locking drum is inoperative, or the angle over which the locking drum is recessed, is $360 - \gamma$. The shape of the recess must be designed in a way that it does not impede the motion of the driven gear.

Machining of a Geneva wheel does not involve difficulties because the contours are formed by circles and straight lines. For reasons already pointed out, the backlash between the rollers and slots should be reduced to a minimum.

Internal Geneva Mechanism: Similarly to conventional gears, Geneva mechanisms can be used for imparting rotation in the same direction as that of the driving gear.

In *Fig.* 13*a* is shown an internal Geneva mechanism with five slots, in the position when the driven gear commences moving, and in *Fig.* 13*b* a general position during the period of motion. These figures may serve for investigating the properties of internal Geneva mechanisms having generally n slots.

Here again, only mechanisms will be considered where the driving rollers enter and leave the slots tangentially so that the motion starts and ends without shock.

It is possible to use the equations derived for external Geneva mechanisms, and to replace n by $(-n)$, or β by $(-\beta)$. In this case, some results appear negative, and although the negative results can be interpreted they may easily cause confusion. The internal Geneva mechanisms will, therefore, be considered separately; but as the derivation of the equations is analogous to that for external mechanisms, the treatment will be more concise.

Geometry: The angle β_0 of the driven gear, *Fig.* 13*a* is

$$\beta_0 = \frac{\pi}{n} \qquad (1a)$$

The angle α_0 of the driving gear is

$$\alpha_0 = \frac{\pi}{2} + \beta_0 = \frac{\pi}{n}\,\frac{n+2}{2} \qquad (2a)$$

The ratio of gearing is

$$\varepsilon = \frac{\alpha_0}{\beta_0} = \frac{n+2}{2} \qquad (3a)$$

If the center distance is a, the radii of driving and driven gears are

$$r_1 = a \sin \beta_0 \qquad (4a)$$

$$r_2 = a \cos \beta_0 \qquad (5a)$$

and their ratio

$$\mu = \frac{r_2}{r_1} = \cot \beta_0 \qquad (6a)$$

The length of the slot is determined by

$$s \geqq a + r_1 = a\,(1 + \sin \beta_0) \qquad (7a)$$

The arc of the locking drum is

$$\gamma = 2\left(\pi - \frac{\pi}{2} - \frac{\pi}{n}\right) = \frac{\pi}{n}\,(n-2) \qquad (8a)$$

The duration of motion, related to the duration of one revolution of the driving shaft, is

$$\nu = \frac{2\,\alpha_0}{2\pi} = \frac{n+2}{2\,n} \qquad (9a)$$

Table 3—Internal Geneva Mechanisms

n	β_0	α_0	ε	$\frac{r_1}{a}$	$\frac{r_2}{a}$	μ	$\frac{s}{a}$	γ	ν	$\left(\frac{d\beta}{d\alpha}\right)_0$	$\left(\frac{d^2\beta}{d\alpha^2}\right)_{-\alpha_0}$	$\left(\frac{d^3\beta}{d\alpha^3}\right)_0$
Stations	Eq. 1a	Eq. 2a	Eq. 3a	Eq. 4a	Eq. 5a	Eq. 6a	Eq. 7a	Eq. 8a	Eq. 9a	Eq. 12a	Eq. 14a	Eq. 18a
3	60°	150°	2.5	0.8660	0.5000	0.5774	1.8660	60°	0.8333	0.464	1.732	0.01786
4	45°	135°	3	0.7071	0.7071	1.0000	1.7071	90°	0.7500	0.414	1.000	0.04163
5	36°	126°	3.5	0.5878	0.8090	1.3764	1.5878	108°	0.7000	0.370	0.7265	0.06053
6	30°	120°	4	0.5000	0.8660	1.7320	1.5000	120°	0.6667	0.333	0.5774	0.07475
7	25°43′	115°43′	4.5	0.4339	0.9009	2.0765	1.4339	128°34′	0.6429	0.303	0.4816	0.08332
8	22°30′	112°30′	5	0.3827	0.9239	2.4142	1.3827	135°	0.6250	0.277	0.4142	0.08936
9	20°	110°	5.5	0.3420	0.9397	2.7475	1.3420	140°	0.6111	0.255	0.3640	0.09313
10	18°	108°	6	0.3090	0.9511	3.0777	1.3090	144°	0.6000	0.236	0.3249	0.09519
∞	0°	90°	∞	0	1	∞	1	180°	0.5000	0	0	0

As here again the substitution of 1 or 2 for n in the previous equations leads to values useless from a practical point of view, the smallest whole number of n is 3.

TABLE 3 contains the values considered in the foregoing, for the same numbers of stations as TABLE 2. While for external Geneva mechanisms the proportion ν of motion in one cycle is increasing up to 0.5 (with increasing number of stations), for internal mechanisms it is larger than 0.5, and approaches that value with increasing number of stations. With increased duration of motion, the kinematic properties can be expected to be more favorable than for external mechanisms.

As the motion of internal Geneva mechanisms occupies more than half a revolution of the driving gear, it is not possible to provide more than one driving roller, and there are no modifications analogous to those described for external Geneva mechanisms.

KINEMATICS: In *Fig.* 13*b* is shown an internal Geneva mechanism in a position during the period of motion when the driving gear is at an angle α, and the driven gear at an angle β beyond the central position.

The distance of the driving roller from the center of the driving gear is, according to Equation 4*a*, AC $= r_1 = a \sin \beta_0$. The distance BC $= \rho$ of the driving roller from the center of the driven gear is

$$\rho = \sqrt{a^2 + r_1^2 + 2ar_1 \cos \alpha}$$

$$= a\sqrt{1 + \sin^2 \beta_0 + 2 \sin \beta_0 \cos \alpha}$$

and

$$\sin \beta = \frac{r_1}{\rho} \sin \alpha = \frac{\sin \beta_0 \sin \alpha}{\sqrt{1 + \sin^2 \beta_0 + 2 \sin \beta_0 \cos \alpha}}$$

Therefore,

$$\beta = \sin^{-1} \frac{\sin \beta_0 \sin \alpha}{\sqrt{1 + \sin^2 \beta_0 + 2 \sin \beta_0 \cos \alpha}} \quad \text{(10a)}$$

With the angular velocity of the driving gear equal to unity, the angular velocity of the driven gear is

$$\frac{d\beta}{d\alpha} = \frac{\sin \beta_0 (\cos \alpha + \sin \beta_0)}{1 + \sin^2 \beta_0 + 2 \sin \beta_0 \cos \alpha} \quad \text{(11a)}$$

The distance ρ reaches in the central position ($\alpha = 0$) its maximum, and it is not as obvious as for external Geneva mechanisms that the maximum angular velocity pertains to that position. However, it can readily be found by means of the second and third differential coefficients, to be derived below.

The substitution of $\alpha = 0$ in Equation 11*a* leads to

$$\left(\frac{d\beta}{d\alpha}\right)_0 = \frac{\sin \beta_0}{1 + \sin \beta_0} = \frac{\sin \beta_0}{2 \cos^2 \left(\frac{\pi}{4} - \frac{\beta_0}{2}\right)} \quad \text{(12a)}$$

The first expression of this equation can easily be obtained from *Fig.* 13*a* without calculus.

The angular acceleration of the driven gear is

$$\frac{d^2\beta}{d\alpha^2} = -\frac{\sin \beta_0 \cos^2 \beta_0 \sin \alpha}{(1 + \sin^2 \beta_0 + 2 \sin \beta_0 \cos \alpha)^2} \quad \text{(13a)}$$

The angular acceleration at the start of motion is obtained by substituting $\alpha = -\alpha_0 = -(\beta_0 + \frac{1}{2}\pi)$ in Equation 13*a*

$$\left(\frac{d^2\beta}{d\alpha^2}\right)_{-\alpha_0} = \tan \beta_0 \quad \text{(14a)}$$

The third differential coefficient of β with regard to α is

$$\frac{d^3\beta}{d\alpha^3} = -\sin \beta_0 \cos^2 \beta_0 \times$$

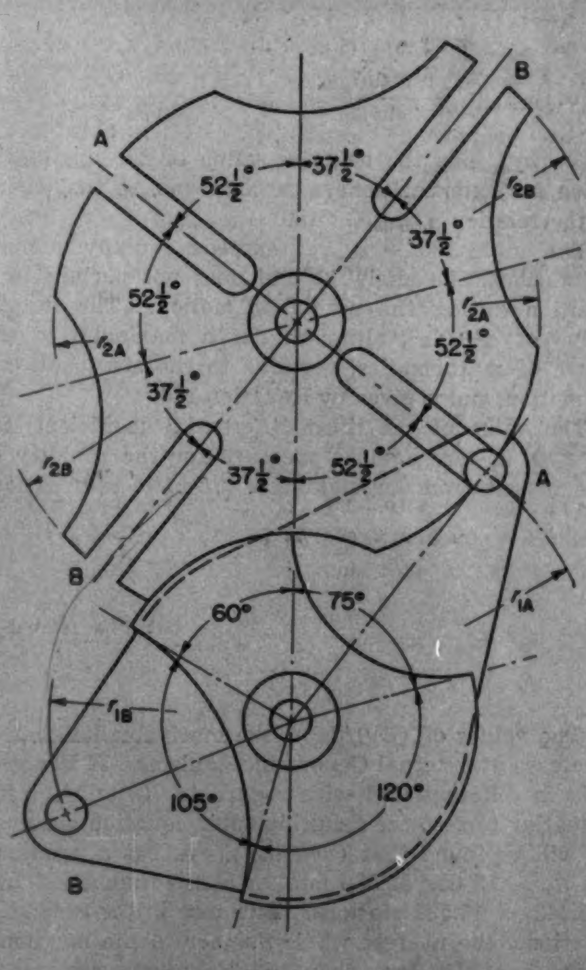
$$\frac{-2 \sin \beta_0 \cos^2 \alpha + (1 + \sin^2 \beta_0) \cos \alpha + 4 \sin \beta_0}{(1 + \sin^2 \beta_0 + 2 \sin \beta_0 \cos \alpha)^3} \quad \text{(15a)}$$

The maximum of the angular acceleration occurs where $d^3\beta/d\alpha^3 = 0$, that is, where $-2 \sin \beta_0 \cos^2 \alpha + (1 + \sin^2 \beta_0) \cos \alpha + 4 \sin \beta_0 = 0$. The solution is

$$\cos \alpha = \frac{1 + \sin^2 \beta_0}{4 \sin \beta_0} \pm \sqrt{\left(\frac{1 + \sin^2 \beta_0}{4 \sin \beta_0}\right)^2 + 2}$$

and as the value under the radical is larger than 1, only the minus sign is to be used. Therefore,

Fig. 12—Irregular Geneva mechanism with four slots and two rollers



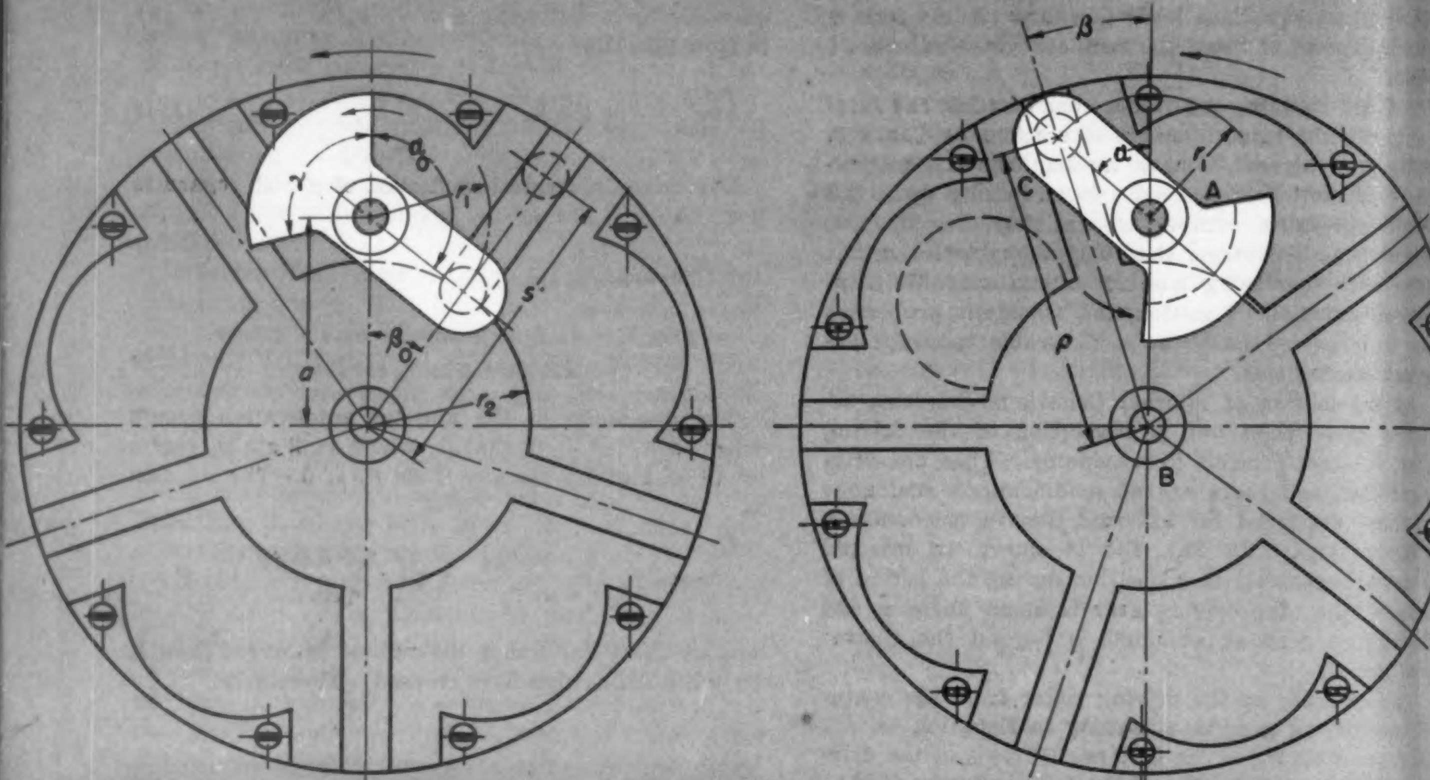


Fig. 13—Internal Geneva mechanisms in the position at the commencement of motion, *a*, and in a general position during the period of motion, *b*

$$\cos \alpha_{max} = \frac{1 + \sin^2 \beta_0}{4 \sin \beta_0} - \sqrt{\left(\frac{1 + \sin^2 \beta_0}{4 \sin \beta_0}\right)^2 + 2}$$

Cos α_{max} has the negative value of the analogous value for external Geneva mechanisms, so that there is the relation $\alpha_{max\text{-}int} = 180 - \alpha_{max\text{-}ext}$.

The angle $180 - \alpha_{max\text{-}ext}$ exceeds, for any number of stations, the angle α_0, and does not pertain to a position during the period of motion. The largest value of $d^2\beta/d\alpha^2$, although not a maximum in the sense of mathematics, pertains to the start and end of motion, and is given by Equation 14*a*.

The value of the third differential coefficient, for $\alpha = 0$, is here again a measure for the rapidity of the transit from angular acceleration to retardation:

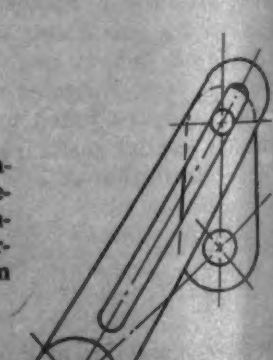
$$\left(\frac{d^3\beta}{d\alpha^3}\right)_0 = -\frac{\sin \beta_0 \cos^2 \beta_0}{(1 + \sin \beta_0)^4}$$

$$= -\frac{\sin \beta_0 \cos^2 \beta_0}{16 \cos^8 \left(\frac{\pi}{4} - \frac{\beta_0}{2}\right)} \quad \text{(18a)}$$

The values of $(d^3\beta/d\alpha^3)_0$ are much smaller than in the case of external Geneva mechanisms. If Equation 18*a* is differentiated with regard to β_0, and if after equating to zero the resulting cubic equation is solved, it will be found that $(d^3\beta/d\alpha^3)_0$ reaches a maximum at $\beta_0 = 15$ deg 32.536 min, or at the number of 180/15.542 = 11.581 stations. But even in the case of 12 stations, the nearest whole number to the maximum, $(d^3\beta/d\alpha^3)_0$ is less than -0.1 radians per second squared per second. The motion of internal gears near to the central position can, therefore, be considered as uniform for practical purposes.

The graphs of *Fig.* 15 show, for an internal Geneva mechanism with four stations, β, $d\beta/d\alpha$, and $d^2\beta/d\alpha^2$ plotted against α. The motion is confined to the period from -135 to $+135$ deg. For the remaining 90 deg, the period of standstill, $d\beta/d\alpha$ and $d^2\beta/d\alpha^2$ should be zero, and β should be a horizontal line in continuation of the value reached at $\alpha = 135$ deg. Instead, the three curves are indicated in dotted lines as if

Fig. 14—Slit-bar mechanism with the same kinematic properties as combined external and internal Geneva mechanism with five stations



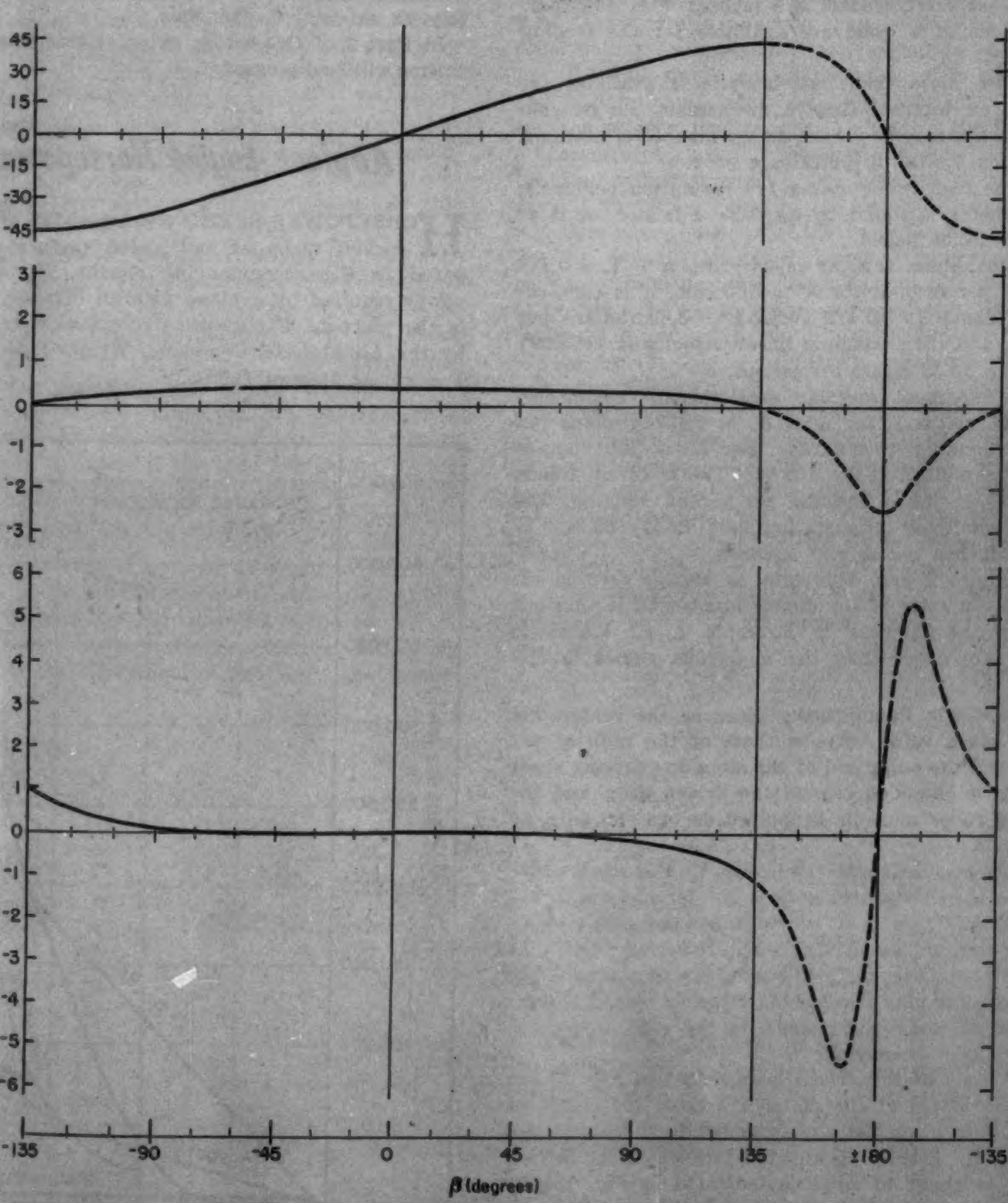
Equations 10*a*, 11*a*, and 13*a* were valid also in the period of standstill. These portions of the graphs will readily be recognized as the mirror image of the graphs in *Fig.* 6 for an external Geneva mechanism with four stations.

The complete range of the graphs in *Fig.* 15 pertains to a slit-bar mechanism as used for the quick return motion of shaping machines. *Fig.* 14 shows a slit-bar mechanism which has the same kinematic features as the combined external and internal Geneva mechanisms with five stations.

It is clear from *Fig.* 15 that the maximum of $d^2\beta/d\alpha^2$ pertains to an imaginary position of an internal Geneva mechanism. The curves also show that the motion near to the central position does not differ greatly from uniform motion.

TABLE 3 contains the characteristic values for internal Geneva mechanisms. The values for an indefinite number of stations are identical for external and internal mechanisms, and pertain to the rack-like mechanism shown in *Fig.* 5. Since it was found in the foregoing that external and internal Geneva

Fig. 15—Diagram of motion for the internal Geneva mechanism with four stations



mechanisms complement each other, as far as kinematics are concerned, it will not be surprising that the values $(d^2\beta/d\alpha^2)_{-\alpha_0}$ are, for the same number of stations, identical.

A comparison between TABLES 2 and 3 reveals that internal Geneva mechanisms, from the point of view of kinematics, are more favorable than external mechanisms. The same is also expressed by *Fig.* 15. That feature is mainly due to the circumstance that the period of motion is increased to more than half of a cycle, at the expense of the standstill. Because of the reduced duration of standstill, the internal Geneva mechanisms have a restricted field of application.

EXAMPLE 4. A mechanism is to be designed for the drive of a feed roller; the amount of feed per revolution of the driving shaft is 4 inches; $N = 100$ rpm; two thirds of a cycle are available for the feeding operation.

Because more than half a cycle is available for motion, an internal Geneva mechanism can be considered. Six may be chosen as the number of stations, for which TABLES 3 indicates $\gamma = \frac{2}{3}$.

As the feed roller makes 1/6 revolution per cycle, its diameter is found by $d\pi/6 = 4$ inches, or $d = 24/\pi = 7.639$ inches.

The maximum angular velocity, for $\omega = 1$, is 0.333 radians per second; for $N = 100$ rpm, it is (according to TABLE 1) 10.472 (0.333) = 3.49 radians per second, and the maximum linear velocity is $\frac{1}{2}(7.639)(3.49) = 13.33$ inches per second.

The maximum angular acceleration (commencement of motion), for $\omega = 1$, is 0.5774-radians per second squared (TABLE 3). For $N = 100$ rpm, it must be multiplied by 109.64 (TABLE 1) or 109.64 (0.5774) = 63.31 radians per second squared. The maximum linear acceleration is $\frac{1}{2}(7.639)(63.31) = 241.81$ inches per second squared.

Examples 1 and 4 pertain to similar feed mechanisms. In spite of the double number of revolutions of the driving gear in Example 4, all kinematic values are lower than the analogous values in Example 1.

DESIGN FOR PRODUCTION: Because the center distance has a value between those of the radii of the inner and the outer end of the slots, the driving shaft cannot be extended beyond the driven gear, and the driving roller must be supported on one end only, as in *Fig.* 2.

In the mechanism shown in *Fig.* 13, the crank which carries the driving roller does not interfere with the driven shaft, so that bearings can be provided on both sides of the driven gear. However, it will be appreciated that, for small numbers of stations, the driving gear may become too large to permit the extension of the driven shaft to the side where the driving gear is moving.

The slots of the driven gear shown in *Fig.* 13 are not terminated at the distance *s* from the center of the driven gear, but are extended to the outer contour of the gear. Only the slot into which the driving roller is about to enter is indicated in *Fig.* 13*a* by dotted lines as terminated at the distance *s*.

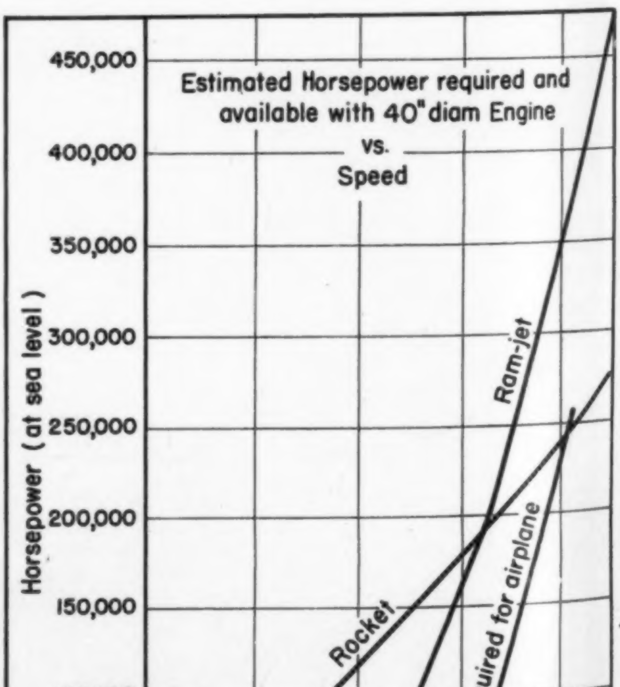
The means for locking the driven gear can be designed analogously to those discussed for external Geneva mechanisms. That is, it can be integral with the parts for imparting the motion, as indicated by dotted lines in *Fig.* 13*b* on the locking drum and locking shoe in front of the driving roller. In spite of a rather small radius of the locking drum, the driven gear is in this case very weak at the tips of the slots. To overcome that drawback, the means for driving and locking may be arranged in different planes, as shown in full lines in *Fig.* 13. The radius of the locking drum can be chosen conveniently large, and the locking shoes may be raised integral parts of the driven gear, or parts separately machined and screwed to the driven gear.

Although machining of internal gears for uniform motion mostly requires special machine tools, internal Geneva mechanisms can be machined in the same way as external mechanisms.

In Part 2 of this series, external star wheel mechanisms will be discussed.

Airplane Engine Horsepower

HORSEPOWER-SPEED characteristics of ram-jet, rocket, turbo-jet and piston engines are compared in the accompanying chart. The increased power required by a plane with an increase in speed is also plotted. These estimated curves were revealed by the Air Materiel Command, Wright-Patterson Air Force Base, Dayton, O.



How To Evaluate SHOCK TESTS

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AS MILITARY requirements increase, the need for equipment designed to withstand shock is becoming substantially more important. Shock tests are often applied to investigate the ability of equipment to withstand the rough handling received in transit and during military service. To specify and evaluate shock tests, it is necessary to understand the fundamentals of the response of a mechanical structure to shock conditions. Some basic considerations in this respect will be discussed in this article.

A typical piece of equipment which may be subjected to shock is the electronic tube illustrated schematically in *Fig.* 1. Consisting of a glass or metal envelope containing filament, grid and plate, the tube will not operate properly if the internal elements become permanently deformed or displaced relative to each other. Therefore, the severity of a shock is indicated not by the maximum acceleration as applied to the base of the tube, but rather by the magnitude of the forces acting upon the elements within the envelope. These forces are not generally a simple function of the acceleration of the base.

A mechanical structure tends to respond to a shock motion in the same manner as another mechanical structure if the natural frequencies of the two structures are equal. As a first approximation, all higher harmonics may be discarded and only the fundamental natural frequency need be considered. If the fundamental natural frequency of each element in the tube is known, an analysis may be carried out by constructing a simulated arrangement as shown in *Fig.* 2. This simulated equipment consists of a base and a number of relatively light cantilever beams, each carrying a load on the free end in the form of a concentrated mass. If the length of each beam and the load which it carries are adjusted to attain a natural frequency equal to the natural frequency of a corresponding element of the vacuum tube, then deflection of each element in response to a shock impact may be determined by measuring the deflection of the respective beam when subjected to an identical shock condition. Styli may be attached to the masses carried by the beams to inscribe a record of each maximum deflection.

Several methods of shock testing may be used; each method subjects the equipment under test to an impulsive change in velocity. In one type of shock-testing device, the equipment to be tested is attached to a plate which is struck on the reverse side by a relatively heavy hammer having a known velocity at the instant of impact. In another type, the equipment is attached to an elevator which is arranged to fall freely under the influence of gravity, the downward velocity being arrested by appropriate means. In investigating the response of simulated equipment,

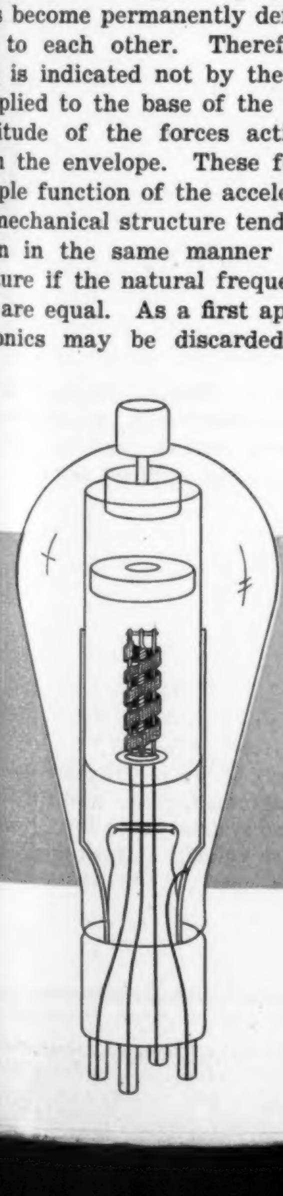


Fig. 1—Left—Electronic tube, schematically shown, is a typical example of components adversely affected by shock load

Fig. 2—Right—Test arrangement simulating structure, mass, and natural frequency of tube elements as shown in *Fig.* 1

the base should be attached to the test plate, or to the elevator platform.

Acceleration of the plate or elevator platform depends on the nature of the applied force which changes the velocity, and may be defined by an acceleration-time diagram. The sinusoidal pattern illustrated in *Fig.* 3 is an idealized acceleration-time diagram and may be considered as an approximation of the less regular diagrams measured on actual testing machines.

Typical displacement-time diagrams which correspond to the acceleration-time diagram in *Fig.* 3 are illustrated by the solid lines in *Figs.* 4 and 5. When the plate is struck by a moving hammer, the acceleration A of the plate increases from zero to a maximum and returns to zero during the time interval T_0. The velocity increases during this period and remains constant thereafter until arrested, the velocity change being V_0 in time T_0. In the case of the falling elevator, the same type of acceleration-time diagram is applicable. The downward velocity of the elevator may be converted, by an elastic arresting device, to a numerically equal upward velocity. If the arresting device is inelastic, the displacement-time diagram for the elevator then exhibits a decrease from the velocity V_0 at the conclusion of the free fall to zero velocity, as illustrated in *Fig.* 5. This change in velocity takes place during the time interval T_0.

The relation between A_0, T_0 and V_0 may be determined by writing the expression for the half-sinusoidal acceleration pattern illustrated in *Fig.* 3:

$$A = A_0 \sin \frac{\pi t}{T_0} \qquad (1)$$

The velocity change resulting from this acceleration pulse is $V_0 = \int A dt$:

$$V_0 = A_0 \int_0^{T_0} \sin \frac{\pi t}{T_0}\, dt = \frac{2 A_0 T_0}{\pi} \qquad (2)$$

As the velocity of the base changes, the beams illustrated in *Fig.* 2 deflect, and the loads carried by the beams then move relative to the base. Vibration of the beams is thus excited, the loads following sinusoidal paths about the path of the base, as illustrated by the broken lines in *Figs.* 4 and 5. The frequency of the sinusoidal motion is the natural frequency of the respective beam-load system. The maximum displacement d of each load relative to the base increases as the natural frequency of the beam-load system decreases. If d becomes greater than that which the beam can withstand without permanent deformation

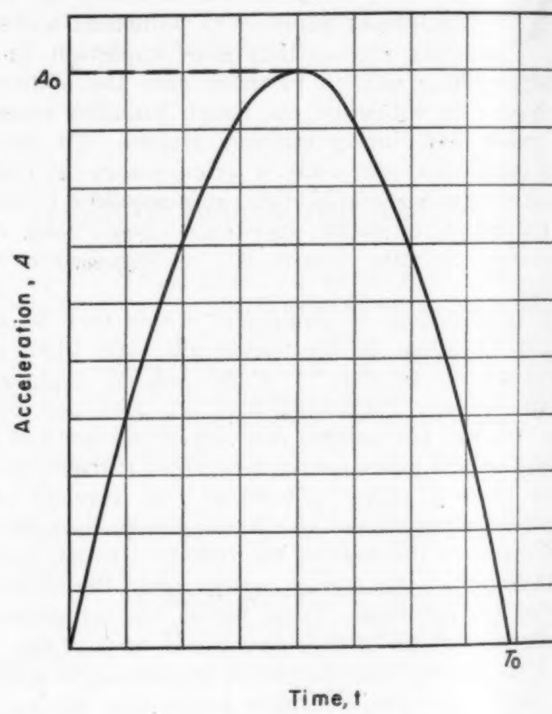


Fig. 3—Above—Idealized acceleration-time diagram representing shock testing machine response to applied impact

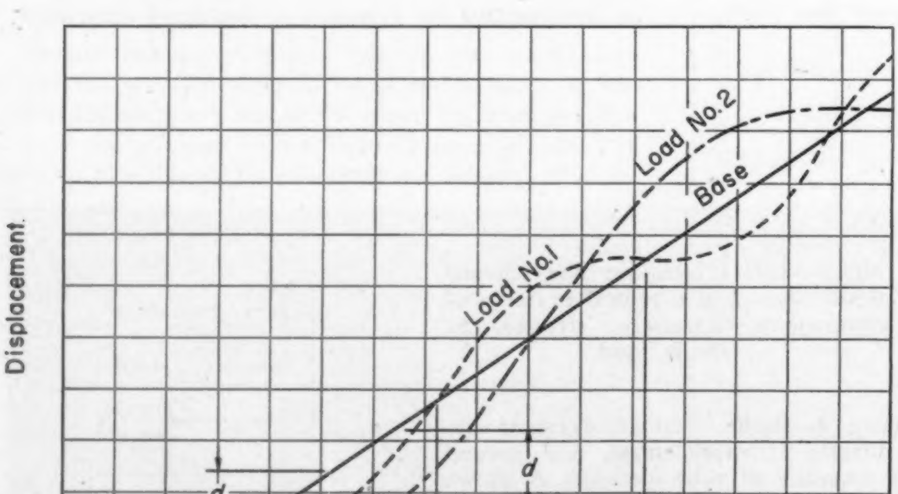


Fig. 4—Left—Displacement-time diagrams for base and two beam-load systems, as in *Fig.* 2, with base velocity unrestrained after impact

or rupture, then the equipment becomes damaged. It is important to note that the ratio of d to the maximum permissible deflection of the beam is a measure of the likelihood of failure of the equipment.

The nature of the conditions that cause deflection of the beams in *Figs.* 4 and 5 should be recognized. It is evident from the occurrence of the deflections that forces are acting on the beams. Neglecting the mass of the beams, the only forces that can cause such deflections are the inertia forces of the loads carried by the beams, i.e., the forces required to accelerate the loads. The beams must have sufficient strength to withstand these inertia forces. The magnitude of the forces may be determined by measuring the deflection of each beam during a shock test, and multiplying this deflection by the respective beam stiffness. It is thus possible to determine the required beam strength.

It is convenient in investigations of this type to use, as a reference, the maximum acceleration of the load carried by the beam. This is readily calculated from the measured maximum deflection d using the equation $a_0 = 4\pi^2 f^2 d$ where f is the natural frequency of the beam-load system in cycles per second. If d is expressed in inches, the maximum acceleration a_0 acquires the unit of inches per second per second. Dividing by the acceleration due to gravity, the maximum acceleration of the load is given in terms of the dimensionless multiple of the acceleration due to gravity, a_0/g. Since the stress in the beam under static conditions results from an acceleration of $1 \times g$, the maximum stress in response to the shock motion is then (a_0/g) times the static stress. In this manner, the maximum stress in any element as a result of shock may be determined from the static stress, after the value of a_0 has been determined from the appropriate natural frequency f and maximum deflection d.

The critical factor in determining the maximum acceleration of the load carried by the beam is the ratio of the periods T_0 and T_1 illustrated in *Figs.* 3 to 5. The period during which the base of the simulated equipment is accelerated is designated T_0 while T_1 is the half-natural period of any beam-load system. Referring to *Fig.* 6 which is plotted from equations 3.2.9 and 3.2.13 in a paper by Mindlin[1], the ordinate is the ratio of the maximum acceleration of the load to the maximum acceleration of the base. Since the base of the simulated equipment is attached rigidly to the shock testing machine, A_0 and T_0 are known from the acceleration-time diagram characteristic of the testing machine. If the natural frequency of the structure undergoing test is known, its half-natural period is readily calculated and the maximum stress may be calculated after a_0 has been determined from *Fig.* 6 . The procedure for making this calculation is illustrated by the following calculations for the maximum stress in the thin plate shown in *Fig.* 7.

The circular steel plate shown in *Fig.* 7 is built-in at the edge, and supports a 20-lb load at the center. The inner and outer radii of the thin section are 1.5 and 4 inches, respectively, and the thickness is 0.1-inch. This plate is part of a machine which is subject to a shock load causing a maximum acceleration of $30g$ during 0.011-sec. The motion due to shock is perpendicular to the plate and it is desired to calculate the maximum stress resulting from the shock.

As previously noted, it is necessary to determine first the fundamental natural frequency f_N of the system, and the static stress in the plate. The natural frequency is calculated from the well known equation

$$f_N = 3.13 \sqrt{\frac{1}{\delta}} \qquad (3)$$

where δ is the static deflection of the steel plate under the influence of the 20-lb load. An equation[2] for the static deflection δ is

$$\delta = \frac{0.217\,\alpha^2 - 0.434 + \dfrac{0.217}{\alpha^2} - 0.868\,(\log_e \alpha)^2}{\alpha^2 - 1} \times \left(\frac{Pr_0^2}{Eh^3}\right) \qquad (4)$$

where P = total load on plate, lb; r_0 = outer radius of plate, inches; E = Young's modulus, psi; h = thickness of plate, inches; and α = ratio of outer to

[1] References are tabulated at end of article.

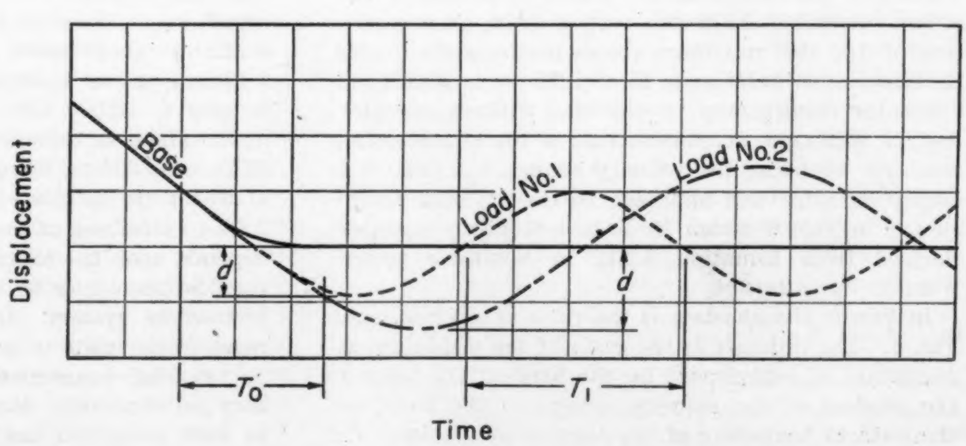


Fig. 5—Displacement-time diagrams for base and two beam-load systems, as in *Fig.* 2, with base velocity arrested after impact

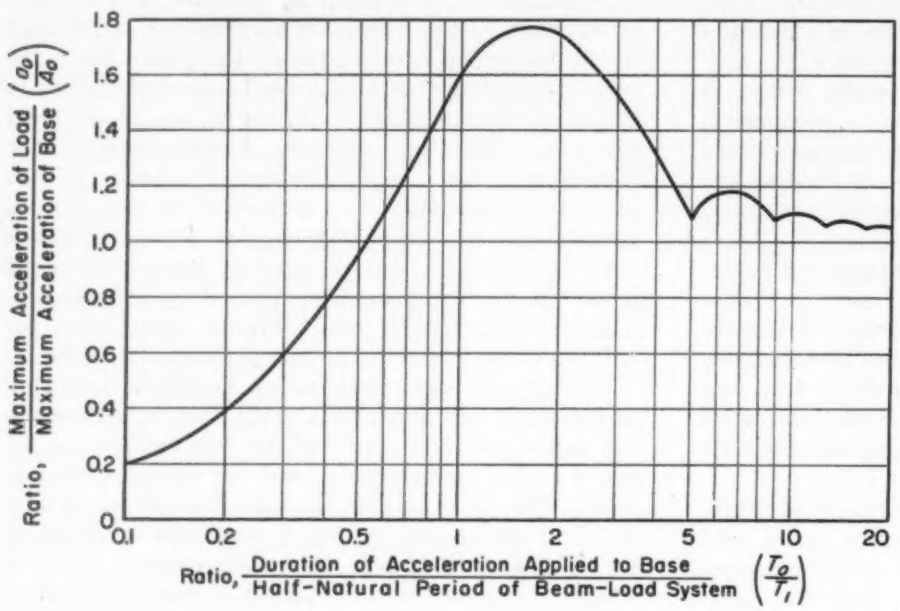
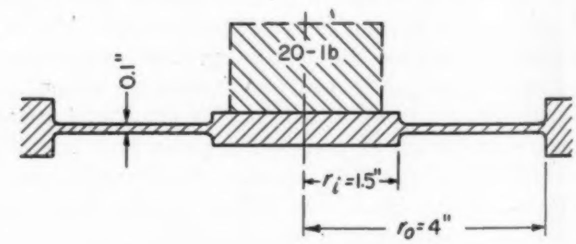


Fig. 6—Left—Relationship of load acceleration and base acceleration of test arrangement in *Fig.* 2, when subject to acceleration as represented in *Fig.* 3

Fig. 7—Below—Thin circular steel plate, wherein the mass is light in proportion to the supported load, resulting in conditions similar to *Figs.* 1 and 2



inner radius. Substituting known values in Equation (4), the resulting static deflection is $\delta = 5.33(10^{-4})$ inches. Natural frequency of the loaded plate may now be calculated using Equation 3 from which $f_N = 136$ cycles per second.

Maximum static stress σ in the steel plate as a result of the static load is calculated by the equation[2]:

$$\sigma = \left(\frac{0.9549\, \alpha^2 \log_e \alpha}{\alpha^2 - 1} - 0.4775\right) \frac{P}{h^2} \qquad (5)$$

Substituting known values, the stress is $\sigma = 1225$ psi.

From the calculated natural frequency, 136 cycles per second, the half-natural period of the circular plate and its load is $T_1 = \frac{1}{2}(1/f_N) = 3.68(10^{-3})$ sec. Inasmuch as $T_0 = 0.011$-sec $= 11(10^{-3})$ sec, the ratio $T_0/T_1 = 11/3.68 = 3.0$. From *Fig.* 3 at this value, the ratio of maximum acceleration of load to maximum acceleration of base, a_0/A_0, is seen to be 1.5. Since the maximum acceleration A_0 of the base is that specified in the shock test, $30g$, the maximum acceleration of the load is $1.5 \times 30g = 45g$. The static stress calculated, 1225 psi, results from an acceleration of $1g$; the maximum stress in the plate during the shock test therefore is 45×1225 psi $= 55{,}125$ psi.

Similar results may be obtained without considering the maximum acceleration A_0 of the shock-testing machine, by using the velocity change V_0. The necessary data for this approach to the problem are included in *Fig.* 8 which is plotted from an equation, derived from Equation 3.2.12 in Mindlin's paper[1], wherein $V_0 = 2\sqrt{2gh}$.

In *Fig.* 8, the abscissa is the ratio of periods, as in *Fig.* 6. The ordinate is the ratio of the maximum acceleration a_0 experienced by the load on the beam to the product of the velocity change of the base, and the natural frequency of the beam-load system. The maximum stress in the plate shown in *Fig.* 7, as a result of a shock load causing maximum acceleration A_0 equal to $30g$ of duration T_0 equal to 0.011-sec, is calculated as follows:

Velocity change V_0 is calculated using Equation 2, with the result $V_0 = 81.2$ inches per sec. From *Fig.* 8, at the abscissa ratio $T_0/T_1 = 3.0$ the value of the ordinate ratio is found to be 1.63. From the ordinate parameter of *Fig.* 8, the maximum acceleration of the load is

$$a_0 = V_0\, f_0 \left(\frac{a_0}{V_0\, f_N}\right) \qquad (6)$$

and substituting $V_0 = 81.2$ and $f_N = 136$ previously found, $a_0 = 18{,}000$ inches per second per second. The maximum acceleration of the load when expressed as a dimensionless multiple of gravitational acceleration is $a_0/g = 18{,}000/386 = 46.6$. The maximum stress in the plate, as calculated thus, is the product $46.6 \times 1225 = 57{,}085$ psi compared with the maximum stress of 55,125 psi calculated when *Fig.* 6 was used.

The usefulness of the data included in *Figs.* 6 and 8 depends upon the extent to which the structure under consideration may be represented by a single-degree-of-freedom system. In the test example, *Fig.* 7, the mass of the plate is small relative to that of the supported load, consequently, realistic calculated results may be expected. Many structures are not adapted to such simplified analysis because of distribution of mass and stiffness, with joints and fasteners having unknown characteristics, or because of two or more

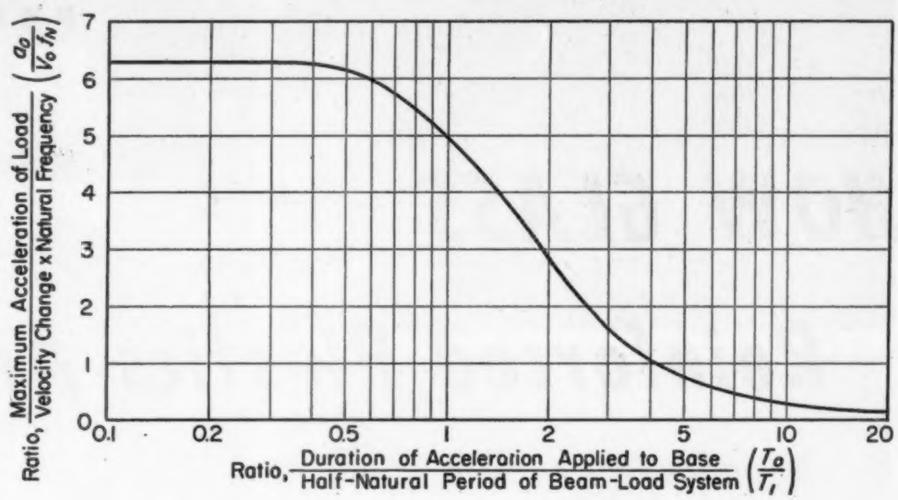


Fig. 8—Relationship of load acceleration, velocity change of base, and natural frequency of a beam-load system as in *Fig.* 2 in response to acceleration as shown in *Fig.* 3

lumped masses with corresponding discrete degrees of freedom. In such instances, the equivalent single-degree-of-freedom system may be difficult to formulate. *Figs.* 6 and 8 then become of less value in a quantitative sense, but indicate in a qualitative manner the parameters which are of significance in specifying and evaluating shock tests.

The value of the diagrams is enhanced by consideration of certain limiting conditions. If the ratio T_0/T_1 is large, the beam vibrates through several complete cycles while the acceleration is being applied to the base. This condition is represented at the right side of *Fig.* 6, and the ratio a_0/A_0 is near unity when T_0/T_1 is greater than approximately 5, except for the ripples which reflect the relatively light effect of the maximum beam deflection matching and mismatching the maximum acceleration of the base.

If the ratio of periods T_0/T_1 is small, the acceleration of the base reaches a maximum and then returns to zero before the deflection of the beam has reached a maximum. In this case, the beam-load system tends to be insensitive to the maximum acceleration of the base, A_0. It is more likely to sense changes in velocity, and the maximum deflection of the beam tends to be proportional to the velocity change of the base V_0, as is illustrated at the left side of *Fig.* 8. The maximum acceleration of the load carried by the beam is directly proportional to the velocity change of the base and to the natural frequency of the beam-load system, and independent of the maximum acceleration A_0 of the base, when the ratio of periods T_0/T_1 is less than approximately 0.5. When the ratio T_0/T_1 is greater than 0.5 but less than 5, the maximum acceleration experienced by the load is not in direct proportion either to the velocity change or to the maximum acceleration of the base. A more complicated relationship then applies because of transient resonance between the beam-load system and the base.

Several practical conclusions may be drawn from the results illustrated in *Figs.* 6 and 8. For a shock test which embodies a sharp impact, T_0 is small and the left sides of *Figs.* 6 and 8 apply, for stresses in structures of the equipment then tend to be directly proportional to the velocity change embodied in the shock test, except where very rigid structures are involved. The same result is obtainable with nonrigid structures, when the impact is cushioned, if the ratio of periods T_0/T_1 is small. The maximum acceleration experienced by the base of the equipment is significant only when the impact is cushioned and the equipment has relatively rigid structures.

As an approximation, the specification for a shock test may be set forth in simple numerical terms by specifying the velocity change and the maximum acceleration, the velocity change being directly proportional to the area under the acceleration-time curve as indicated by Equation 2. The duration of the acceleration pulse is thus defined, provided the maximum acceleration and the shape of the acceleration-time diagram are known. In a practical sense, the duration is defined only approximately because testing machines of the types mentioned tend to exhibit acceleration-time diagrams having considerable similarity.

The specification of a shock test in terms of velocity change and maximum acceleration tends to give rigorously correct results for both relatively rigid and nonrigid structures, as indicated by *Figs.* 6 and 8. It is somewhat indefinite, however, for structures of intermediate stiffness because the exact shape of the acceleration-time diagram has some influence upon the response of such structures. This is a second-order effect, which can be eliminated only by specifying the details of the shock testing machine. Equipment subjected to shock tests is susceptible to many subtle influences, and to duplicate exactly the result of a shock test, it is important to use an identical or duplicate machine to avoid inconsistency.

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HOW GLASS Reinforced Plastics Are Molded

Low weight, high impact and good damping characteristics make glass-polyester parts ideal for machines

FORMERLY designed for production as a drawn steel part, this new dust bowl, *Fig.* 1, for the Lewyt vacuum cleaner is designed for molding from glass-reinforced polyester plastic. This low-pressure molded material has excellent characteristics for such parts, namely, high impact resistance, resistance to chipping, and low resonance which reduces operating noise. Use of plastics in this modern cannister type cleaner reduces weight by 3½ pounds over the previous all-metal job.

This cannister for the Lewyt cleaner is produced by the Auburn Button Works Inc. The interesting sequence of steps used in their molding operations is shown in *Figs.* 2 through 7 following. From these operations, some of the salient factors important in design can be readily ascertained.

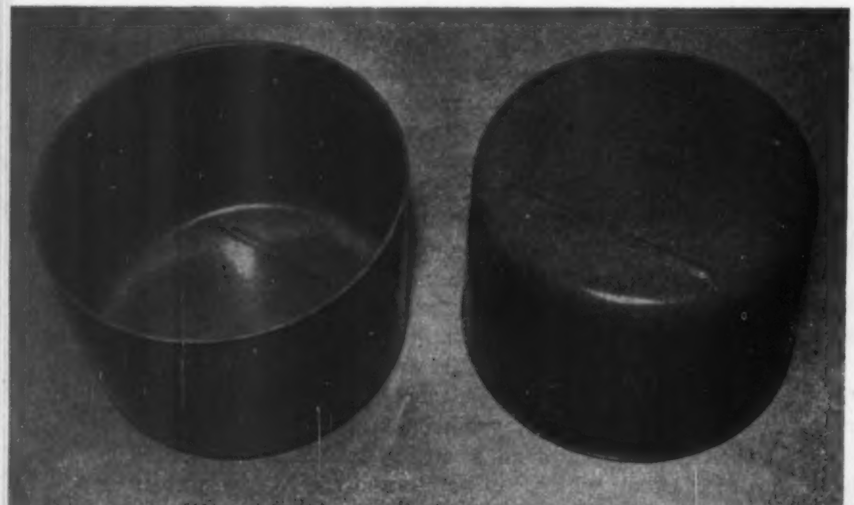
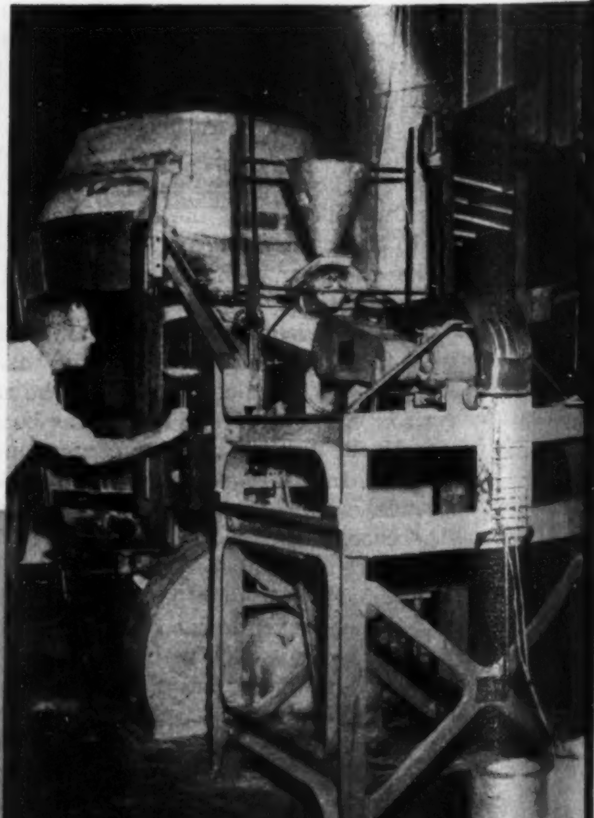


Fig. 1—Above—Top and bottom views of vacuum cleaner dust bowl molded from glass-reinforced polyester resin

Fig. 2—Right—Fiberglas yarn at lower right is drawn into a chopper where it is cut into 2-inch fiber lengths and blown into the top-shaped preforming chamber to the left



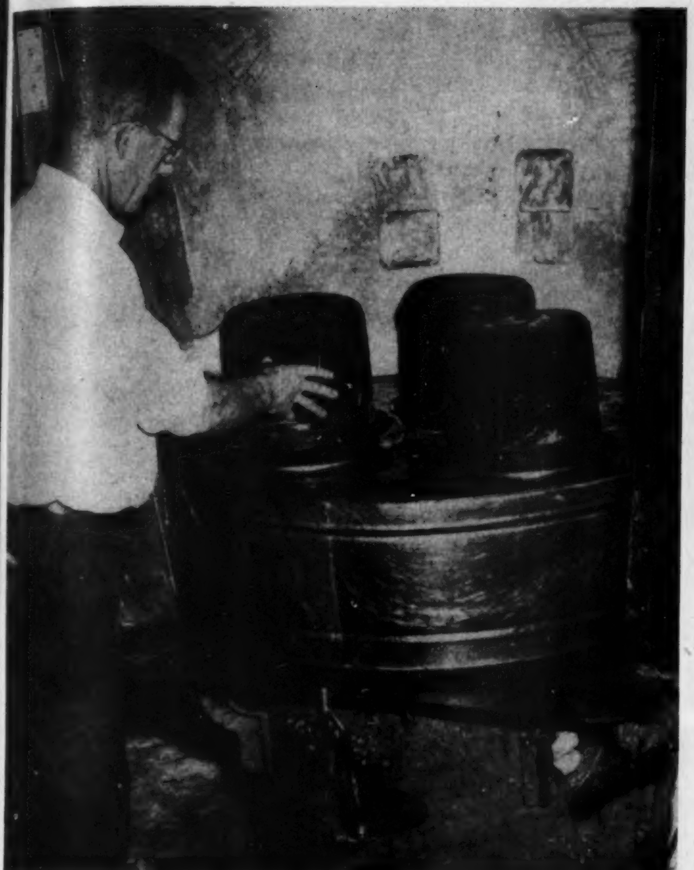


Fig. 3—Above—Forming molds, made from 16-gage steel with ⅛-inch diameter holes spaced to provide 40 per cent open area, are placed over vacuum exhaust ports on the turntable in the preform chamber. An exhaust fan connected by ductwork to the center of the turntable, draws fibres to the preform mold. Fibres run at a rate of about two pounds per minute, and a minimum of three screens is required for maximum production efficiency. Preform cycle for cannister production is 45 seconds

Fig. 4—Above—At the end of the 45-second cycle, the preform is sprayed with Plaskon resin emulsion (2 to 5 per cent by weight). Then preform and screen mold are placed in a recirculating drying oven where air at 300 to 350 F is pulled through the preform to reduce bulk and cure the binder. Curing cycle in oven is 45 seconds

Fig. 5—Left—Preforms are removed from screen molds, weighed (approximately 3 oz), and sent to molding department for final operation in production of cannisters

Fig. 6—Above—Preforms are then placed on a two-cavity mold, where a charge of liquid resin is poured over each of them. The molds are closed for a cure cycle at 250 F with over 100 psi on the mold

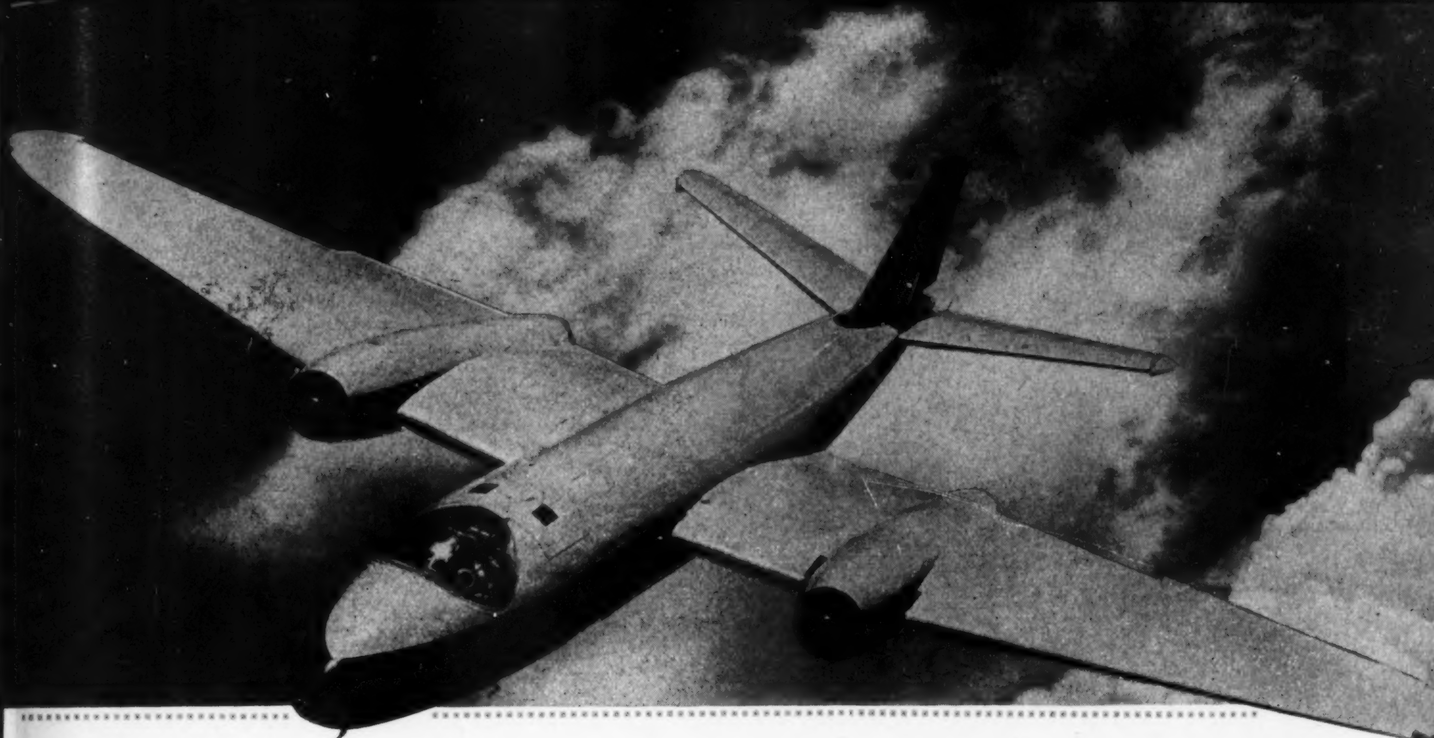
Fig. 7—Left—After curing, the press opens automatically and cannisters are removed by air ejection. No further operations are required except punching holes for hose fittings. The outside of the dust bowl is spray painted a metallic gray to match its steel predecessor

Flight Lab Confirms Results of Simulated Tests

ENGINEERING psychologists are endeavoring to design and develop flight equipment that will permit the human operator to function as efficiently and safely as possible. For this reason, the Aero-Medical Laboratory at Air Materiel Command Headquarters, Dayton, Ohio is using an airborne psychology laboratory in a C-47 aircraft to determine just how a pilot reacts to certain flight conditions.

Equipment itself consists of a motor-generator, sensing units, scoring console and recording consoles. The generating plant, located in the aft section of the cargo compartment, is adjusted for continuous output at altitudes ranging from the ground to 20,000 feet. The sensing units consist of potentiometers and hydraulically operated pick-ups which actuate the scoring and recording consoles. Whenever a pilot adjusts his instruments to correct a flight problem, the instruments record the action.

The scoring console electric stop clocks indicate the length of time a pilot is unable to stay within the allowed tolerance for such variables are airspeed, altitude, pitch, angle of bank, rate of turn, vertical speed, heading and glide path. Whenever he moves outside these tolerances the clocks stop and the percentage of time the clock operates, compared with the total time of the test, indicates the pilot's degree of proficiency. The recording console provides graphic records of aileron, elevator, rudder, throttle, and prop governor position, elevator, rudder and aileron pressure, air speed, altitude, angle of bank, vertical speed, glide path, localizer, rate of turn, pitch, inclinometer, and grip tension on the control wheel. A voice recorder and strategically-placed motion picture camera record the pilot's comments and body movements.



VIBRATION FAILURES

. . . how service behavior of gas-turbine buckets is recorded and analyzed for design data. Continuous record is radioed from plane in flight to a trailer on the ground

By E. Colston Shepherd

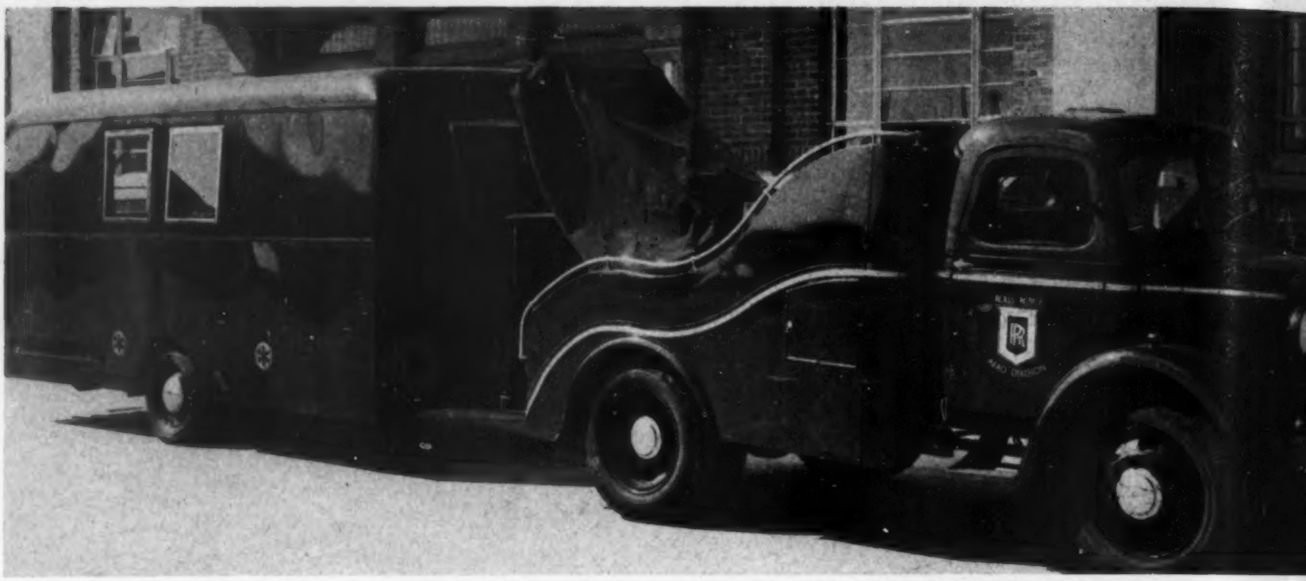
London, England

IN THE development of gas turbines for aircraft, considerable attention has been devoted to the problem of eliminating bucket failures. With certain turbines these failures invariably occur in flight, and still occur only in flight. Although a technique for discovering the causes of the failures has been developed, research workers in England have been unable to induce failures on the test bed resembling those which take place during flight. Investigations, therefore, were organized to allow the testing and recording to be done during flight.

Although telemetering of test data on aircraft structures from air to ground has been a familiar process, it had not been applied to the flight testing of turbine engines. To test turbine buckets in flight, apparatus is required for detecting, identifying, recording and analyzing the vibrations responsible for failure.

Apparatus developed by Rolls-Royce Ltd. for this purpose has been in use for more than a year and has tested Derwent V gas turbines in a Gloster Meteor fighter and Nene gas turbines in an English Electric Canberra bomber, *Fig.* 1. In this equipment, test data are received by radio and recorded on a tape recorder set up permanently in a trailer, *Fig.* 2, so built that it can be towed at 30 mph without damaging the receiving and recording equipment, *Fig.* 3. In the course of some 30 hours of test flying much valuable information has been accumulated. Full interpretation

Fig. 1—Canberra bomber, powered by twin Rolls-Royce jet engines. This type of aircraft was utilized to study the stresses on turbine buckets during flight



of these data awaits the completion of further tests. What makes this test apparatus of special interest is that it is equally applicable to tests in flight or on the test bed and that it allows tests to be made at unusually high speeds and temperatures.

In beginning this investigation the first object was to find out the manner in which the buckets were vibrating and the critical ranges of frequency. This suggested the use of wire strain gages. In these gages, the wire must be capable of withstanding a temperature of 1400 F and centrifugal forces equal to 20,000 times the weight of the gage. To avoid interference with the gas flow past the bucket, the gage wire is recessed into it and cemented to the bucket with the American Quigley company's blue paint. After early tests, in which corrosion of the fine nichrome wire caused the gage to have a short life, a heavier wire (0.002-inch) was used.

The gages are set in two positions near the root of the bucket, one at midchord sensitive to whip vibrations and another at the trailing edge sensitive to torsional vibrations, *Fig.* 4. Use of two gages is necessary because of the difficulty in identifying data from a single gage. The two have proved of great value in this matter despite the fact that the natural frequency of any vibration mode is modified to a large extent by temperature and centrifugal force. The ratio between the stresses at the two standard gage positions and at the usual point of failure was obtained in the laboratory with apparatus employing magnetostrictive transducers, *Fig.* 5. The purpose was to excite the bucket with sufficient energy to yield measurable stresses beyond the range of conventional electromagnetic equipment.

Design of this type of transducer rests on the fact that most magnetic materials (of which nickel is a particularly good example) change their length slightly when magnetized. If an alternating magnetic flux is passed through a rectangular stack of nickel laminations, the stack changes its length by a few millionths of an inch at twice the frequency of the alternating current. If a polarized winding is employed, a greater movement is obtained for a given input and the frequency of the movement becomes equal to that of the supply. For practical purposes the length of the stack is adjusted so that it will resonate at the required frequency. Then if alternating energy is applied at this frequency, the movement may be ten times more than that obtained in the off-resonance conditions.

Movement of such a transducer, however, is not sufficient to generate high enough stress in a turbine bucket for accurate laboratory measurements. Recourse was had, therefore, to a tapered probe which butts against one end of the stack and is rigidly clamped to the turbine bucket near its root at the other, *Fig.* 5. The effect of the probe, which theoretically should be hyperbolic in form, is to give a step-up in the movement with a corresponding step-down in the force available. In other words, the thin end of the probe moves much more than the thick end which butts against the nickel stack. This probe has been used to excite turbine buckets at a frequency of 13,000 per second. Models have been tested to failure with the apparatus at this frequency which is equivalent to a frequency of 11,000 per second in an engine running about 14,000 rpm.

Tests Indicate Vibration Mode

Failures obtained in this way added to the evidence that failures in flight were due to resonance in the same mode. The ratio between the stresses at the various gage positions was also obtained. Identification of modes in the bucket while the engine is in flight could then be made provided the vibration data could be communicated accurately.

For this purpose, mercury slip rings proved of special value. In the conventional type of slip ring, the area of contact between brush and ring is relatively small, requiring high spring pressures to maintain contact. These pressures result in excessive brush wear and frequently cause scouring of the ring. In the mercury slip-ring device, *Figs.* 6 and 7, the whole periphery of the rotating ring is immersed in mercury and the area of contact is thus many times that

Fig. 2—Left—Trailer and tractor used in transporting receiving and recording apparatus to the general vicinity in which plane is flying

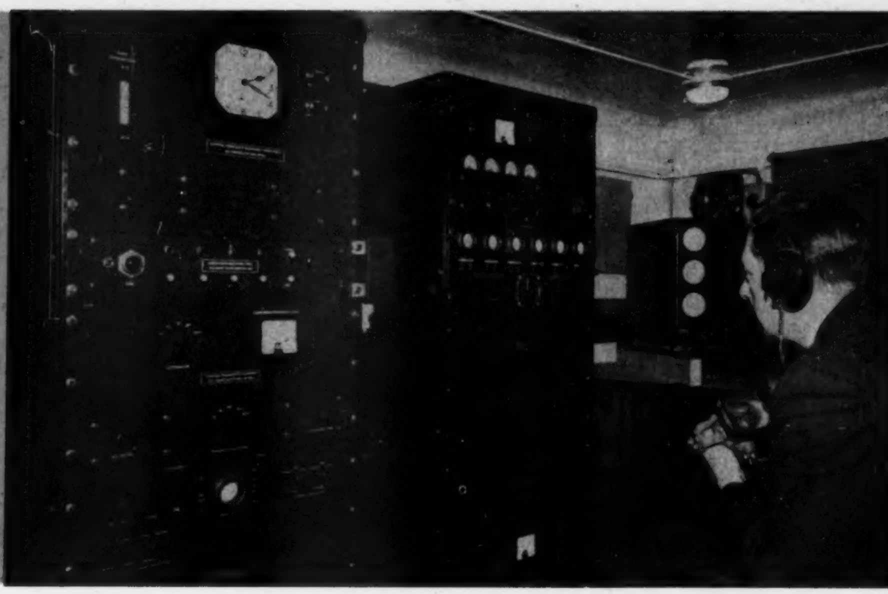


Fig. 3—Right—Receiving and recording equipment installed in the trailer. Operator uses a headphone and microphone for communicating with pilot

obtained with the more usual brushes. These rings reduced the background "mush" so much that nichrome wire of two-thousandth inch could be used in the gages instead of the customary wire of one-thousandth. The lower resistance of these wires gives a signal of a higher voltage for a given strength.

Amplifying equipment for flight signals is the same as that for work on the test bed except, instead of feeding into a cathode-ray tube, it is used to "amplitude modulate" a carrier wave in the VHF radio transmitter normally carried by the aircraft. This works in the 120-megacycle frequency band. Such a system, if used to measure stresses directly, would give serious errors because of fading. For this reason an oscillator, which is in effect an electronic alternator of constant-voltage output, is carried in the aircraft and its output is connected to the radio transmitter about five times a second. During the intervals in the transmission of this calibrating signal from the oscillator, the actual stress signal is transmitted and estimations of stress are made in the trailer on the ground by comparing the amplitude of the stress signal with that of the calibrating signal which, as a matter of interest, is the equivalent of about 10,000 psi stress. To enable the transmitting and receiving equipment to handle the bucket frequencies which are outside the normal limits of speech transmission, the modulation transformer is omitted and the amplifier output is coupled resistively to the modulating tube.

For ordinary test-bed use, the signals are recorded by a continuous-film camera running at 900 inches a second. Long recordings are not considered because of the quantity of photographic material, with the consequent cost in time and labor, that would be

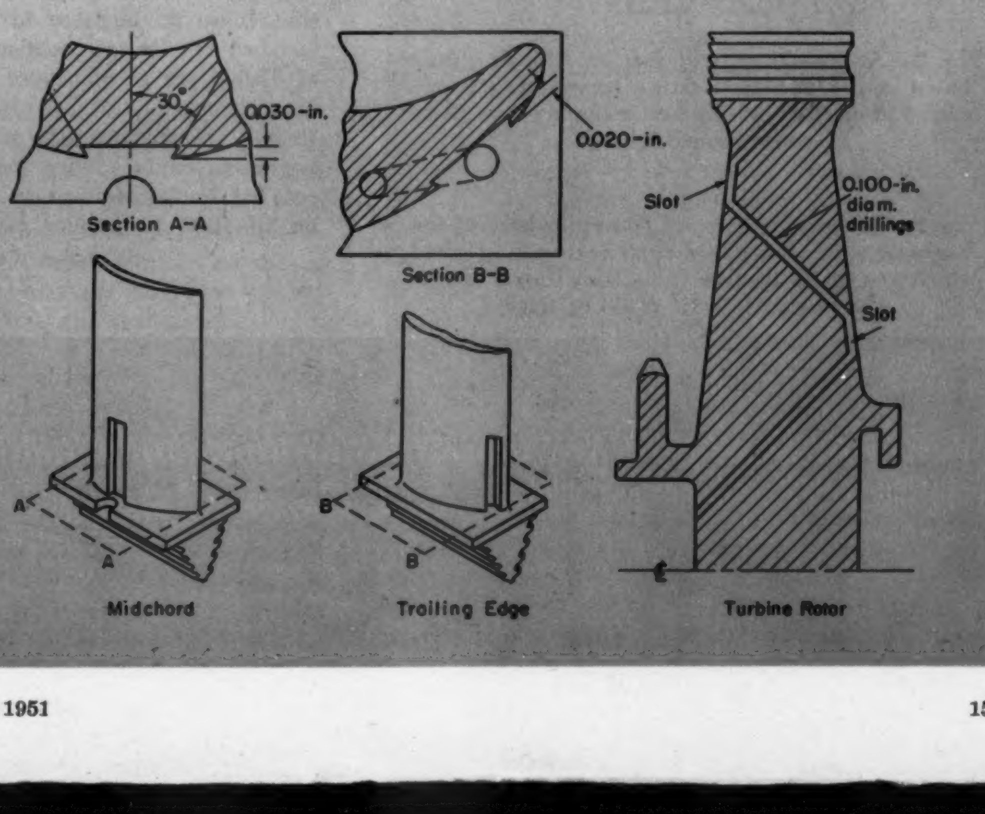
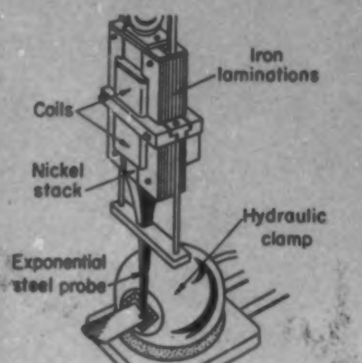


Fig. 4—Positions of the two recesses in which strain gages are placed on the buckets and of slots in the turbine rotor for lacing the strain-gage leads to the slip-ring commutator

Fig. 5—Below — Transducer device to excite vibration in a model of a turbine bucket. Aluminum models failed in this apparatus, giving information from which readings in flight could be adjusted



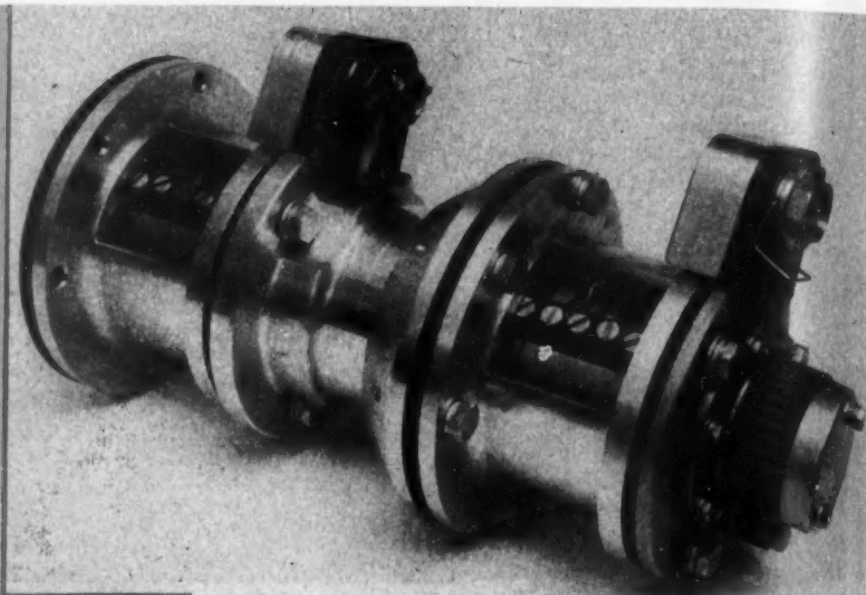


Fig. 6 — Right — Twelve-way slip-ring assembly mounted on the engine to communicate strain-gage data. The slip rings are of the mercury type, permitting use of heavier gage wire on the buckets

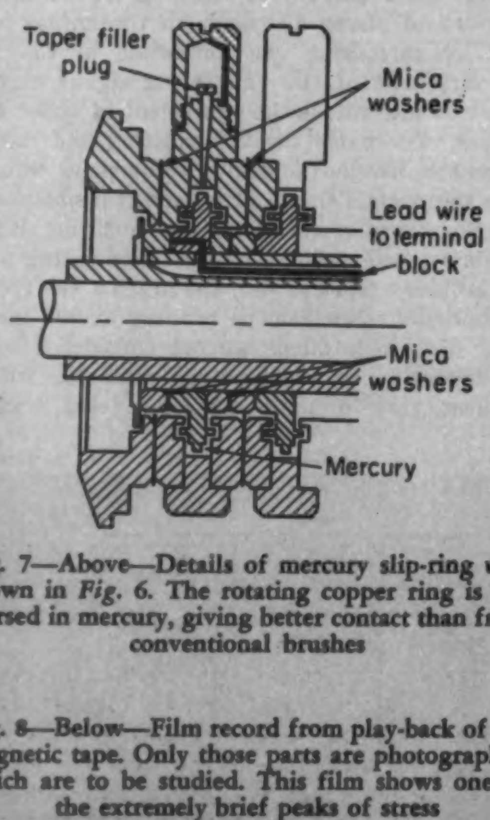
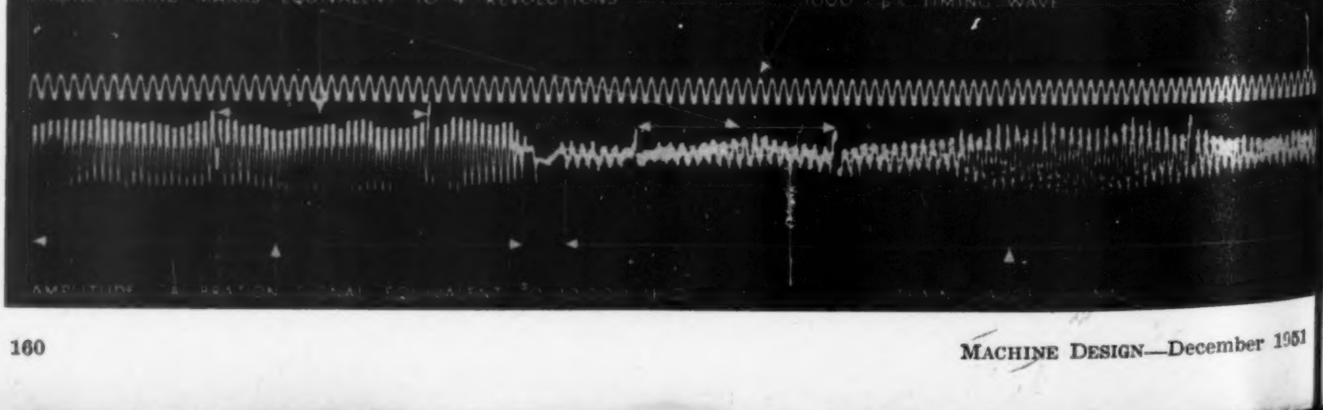


Fig. 7—Above—Details of mercury slip-ring unit shown in *Fig.* 6. The rotating copper ring is immersed in mercury, giving better contact than from conventional brushes

Fig. 8—Below—Film record from play-back of the magnetic tape. Only those parts are photographed which are to be studied. This film shows one of the extremely brief peaks of stress



involved. During recording, precise adjustment of engine speeds is necessary because of the sharpness of the resonance of the buckets. Accurate data on engine speeds would be impossible with single-channel transmission from aircraft to ground, yet without this information it would be difficult to obtain records of the remarkably brief peak stresses.

The dilemma is overcome by recording on magnetic tape the whole signal from the aircraft, including speech from the pilot confirming height, engine speed, etc. The tape is run past the recording head at 30 inches a second. This tape is replayed into a cathode-ray oscillograph and a note is made of the instants corresponding to the peaks in stress. Then, on a subsequent replay, only those peaks are recorded by the high-speed camera, *Fig.* 8. An alternative method of analyzing the results on the ground is to replay the tape into a variable band-width frequency analyzer.

Results with the new apparatus showed that the biggest strains were in the stator vane order and that these do increase in flight. As compared with test-bed results, stresses at frequencies of the order of 13,000 per second were shown to increase at high aircraft speeds and low altitudes by as much as three to one. In this respect, telemetering flight data has begun to explain why there has been such a high rate of bucket failure in service, whereas a failure on the test bed never occurs. It has also brought

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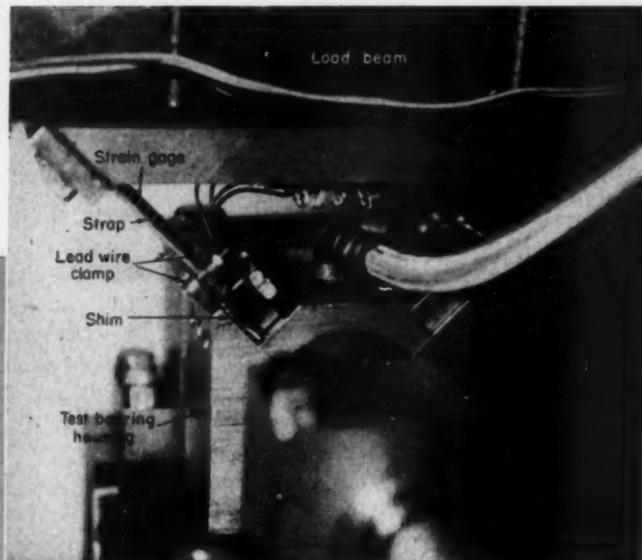
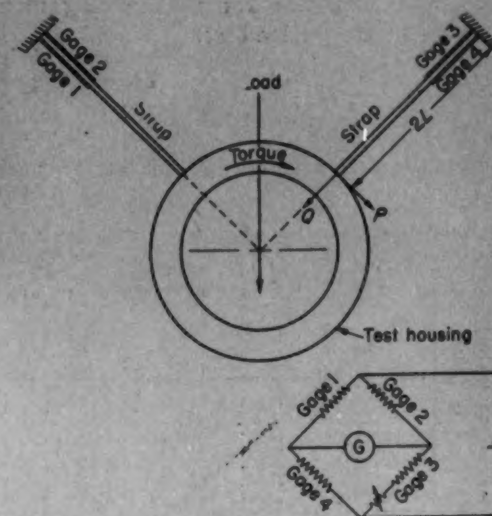


Fig. 1—Left—Torque meter on bearing test stand eliminates friction errors in measurements by utilizing flexible hinges and strain gages

Fig. 2—Below—Diagram of instrument arrangement and strain gage circuit



ELIMINATING FRICTION FROM Torque Measurements

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TORQUE measurements with cradle mounts are subject to the possibility of error because of friction in the support bearings. This friction and resulting error become so objectionable with small torques and high trunnion loads that special antifriction mounts must be used to insure accuracy. For studying this problem, an elastic support system has been developed to replace the trunnion bearings. This system, with thin steel straps supporting the load, *Fig.* 1, has been found to be one of the easiest ways to eliminate the friction error in measuring torques.

The torque may be accurately measured by using electric resistance strain gages bonded to the support straps. This simple system can be made to give measurements with an error of less than 2 per cent if the stress in the straps is primarily bending rather than direct tension due to the load supported by the straps. In the units tested, because of errors in machining and placing the strain gages, a calibration was required to obtain good accuracy.

One such unit, *Fig.* 1, was designed to measure torque on a bearing in a bearing test machine. In this case torque on the test bearing housing was the result of friction in the test bearing. Here the tension load on the straps was variable and might range from 0 to 6000 pounds per strap, whereas the maximum torque was only 150 lb-in. This variable tension on the straps imposed on them an unwanted strain which does not exist in a simple dynamometer mount with a definite weight but which could be eliminated effectively by wiring the strain gages to the bridge circuit shown in *Fig.* 2. Equal tensile strains in the straps do not unbalance the bridge, but bending strains caused by torque are multiplied by four in the measuring resistance.

In the bearing test machine, *Fig.* 1, the strain gages are Baldwin SR-4 Bakelite base, type ABD-1,

bonded to the steel straps with Bakelite cement. Four of these gages, arranged as shown in *Fig.* 2, form a complete bridge circuit which is wired to a Baldwin strain indicator by connecting a lead from each corner of the bridge. The variable measuring resistance and battery are not necessary when balancing against a standard strain indicator.

Effect of tension in the straps upon the torque reading is shown in *Fig.* 3, based upon the following approximate equation for the bending moment produced by the torque loading:

$$M = PL\left(1 - \frac{QL^2}{3EI}\right)$$

where

M = Maximum bending moment in the strap, lb-in.

P = Load on the strap produced by torque, lb (*Fig.* 2)

L = One-half the total length of the strap, in. (*Fig.* 2)

Q = Tensile load on strap, lb (*Fig.* 2)

E = Young's modulus of elasticity of strap material, psi.

I = Moment of inertia of strap, in.^{4}

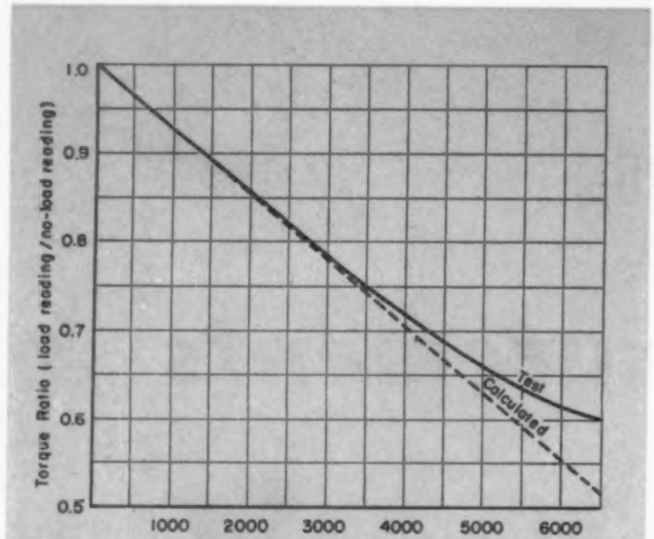
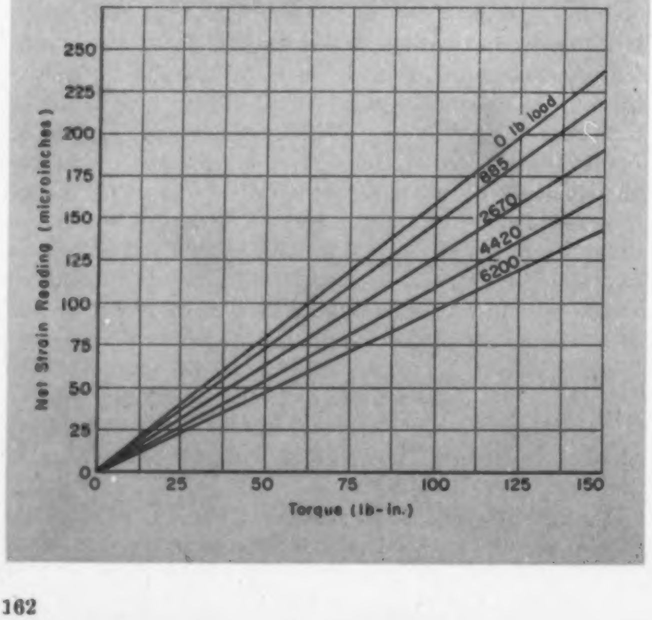


Fig. 3—Above—Effect of load on torque strain reading, comparing test with calculated

Fig. 4—Below—Calibration curves showing the effects of load and torque on strain reading



This curve, *Fig.* 3, is extended to include the rather severe requirements of the bearing test machine where the tension load was large compared to the bending load. *Fig.* 4 shows the same effect on the actual calibration curves for this torque meter. It is interesting to note that the calibration curves are straight lines, thereby considerably reducing the time required for calibration.

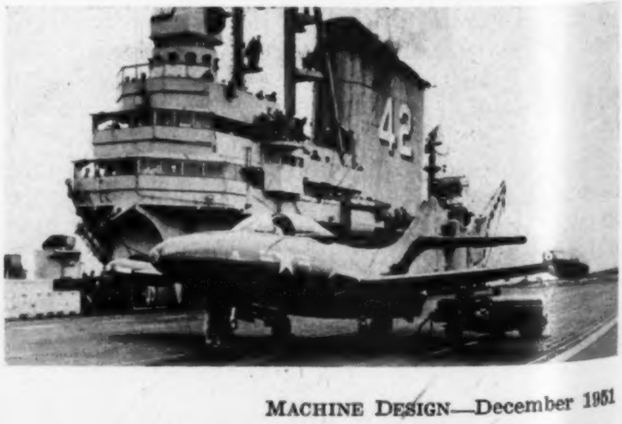
One of the few problems in using this type of torque meter occurs with a variable tensile load; torque is produced by the variable tensile load in the straps if the center lines of the straps do not intersect on the load line as indicated in *Fig.* 2. This difficulty can be overcome by calibrating or by correcting manufacturing errors with the use of shims under the straps, as shown in *Fig.* 1.

When this method is used to measure the torque on a motor, pump, or other unit where the load on the straps is so nearly constant that no accurate adjustment of the strap load line is necessary, the calibration curve will shift, due to any built-in eccentricity, and then will remain constant.

Mobile Power Starts Fighters

A LIGHTWEIGHT, low-slung, extremely maneuverable, three-wheeled Jeep is being produced by O. E. Szekely and Associates as a mobile power plant to energize U. S. Navy jet fighters as well as land-based military planes of various types.

The unit is a self-propelled electric power plant capable of furnishing constant current d-c for starting jet engines, and constant-voltage direct current for starting reciprocating engines and for checking out the electric circuits of airplanes. The generator for the starting power and the auxiliary equipment gets its drive from the center power take-off of a converted Willys-Overland Jeep. The tricycle Jeep is steered by a vertical steering wheel that turns only the tail wheel. The entire unit, complete with special equipment, weighs only 1750 pounds.



Surface Compressive Stress in Gear Teeth

By C. J. Schorsch
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FORMULAS and a composite nomogram are presented in this article for determining the surface compressive stress of straight-tooth spur gears and straight-tooth right-angle bevel gears. Included are solutions for both 14½ and 20-deg pressure angles.

Equations are based on the Hertz formula for the surface compressive stresses produced in contacting cylinders. Mating steel gears with modulus of elasticity of 30,000,000 psi and Poisson's ratio of 0.25 have been assumed. The equations are:

For 14½-deg straight-tooth spur gear

$$s = 6479\sqrt{\frac{w_t}{D}\left(1+\frac{N}{n}\right)}$$

For 20-deg straight-tooth spur gear

$$s = 5627\sqrt{\frac{w_t}{D}\left(1+\frac{N}{n}\right)}$$

For 14½-deg straight-tooth right-angle bevel gear

$$s = 4581\sqrt{\frac{w_t}{A_m}\,\frac{1+\left(\frac{N}{n}\right)^2}{\frac{N}{n}}}$$

For 20-deg straight-tooth right-angle bevel gear

$$s = 3979\sqrt{\frac{w_t}{A_m}\,\frac{1+\left(\frac{N}{n}\right)^2}{\frac{N}{n}}}$$

Nomenclature is as follows: s = surface compressive stress, psi; w_t = unit tangential tooth load, lb per inch; D and d = pitch diameters of large and small spur gears, respectively, inches; N and n = numbers of teeth in large and small gears, inches; A_m = mean cone distance of right-angle bevel gears. The foregoing equations are built into the nomogram on the following page.

EXAMPLE 1: Check the surface compressive stress in the gears of a speed-reducing drive transmitting 1250 hp at 400 rpm input speed. Straight-tooth spur gears have 30 and 150 teeth, 15 and 75-inch pitch diameters ($N/n = 5$), and 25-inch effective face width. First,

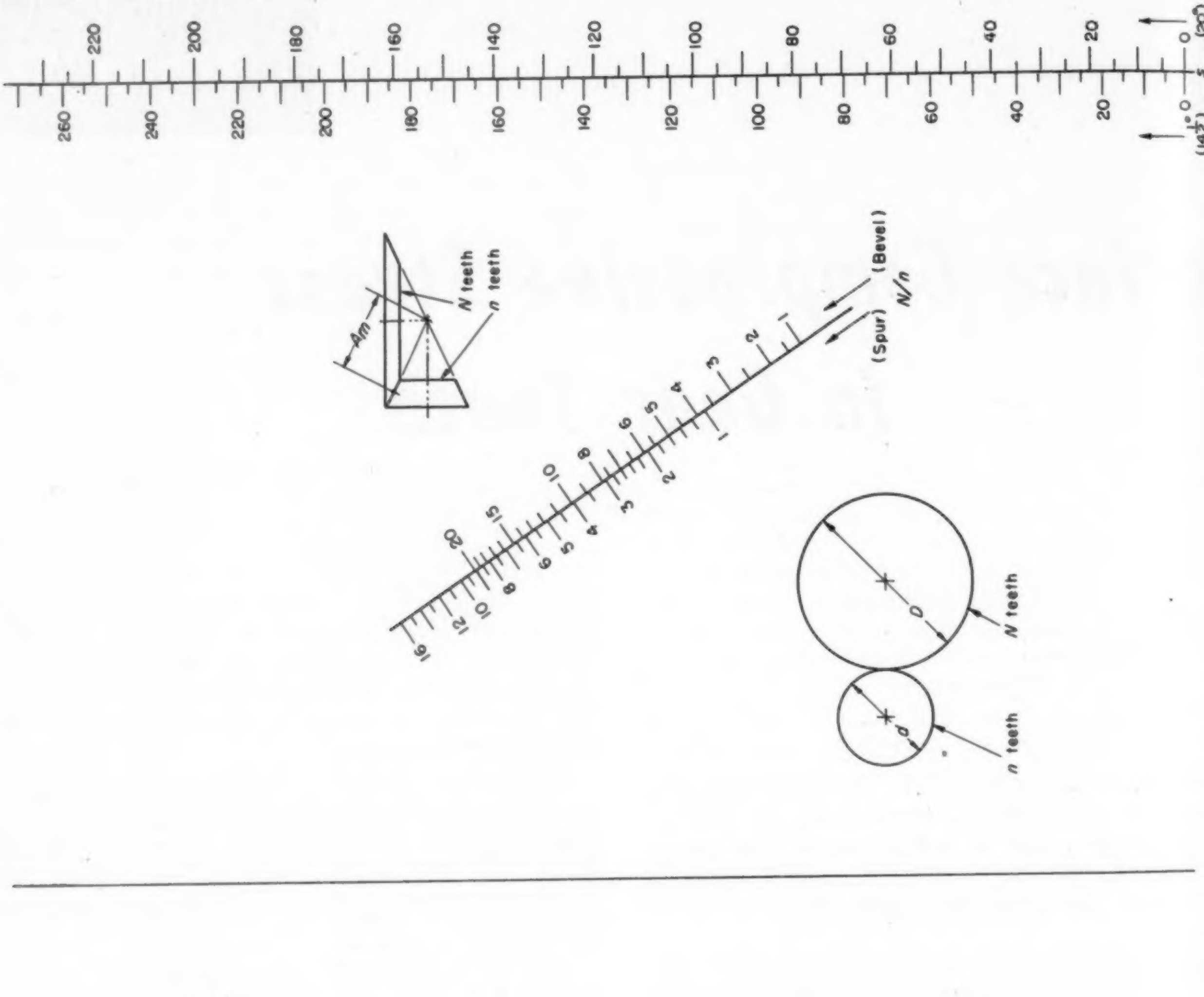
$$w_t = \frac{33{,}000\,P}{vF} = \frac{33{,}000\ (1250)\ (12)}{400\ (\pi)\ (15)\ (25)}$$
$$= 1050 \text{ lb per inch}$$

On the nomogram, project a line from 1050 on the w_t scale through 75 on the sloped D scale to the unmarked center scale. From this latter point, project a line through 5, as labeled on the *spur* side of the N/n scale, to the s scale. For a 14½-deg tooth form, s = 59,000 psi; for a 20-deg form, s = 52,000 psi.

EXAMPLE 2: Check the surface compressive stress in the straight-tooth bevel gears of a right-angle speed increasing unit transmitting 250 hp at 125 rpm output speed. Pitch diameters are 40 and 20 inches for 40 and 20-tooth gears ($N/n = 2$) and effective face width is 7.5 inches. Calculation with these data gives average pitch diameters of 33.333 and 16.667 inches and a mean cone distance, A_m, of 18.6 inches. Then,

$$w_t = \frac{33{,}000\,P}{vF} = \frac{33{,}000\ (250)\ (12)}{125\ (\pi)\ (16.667)\ (7.5)}$$
$$= 2020 \text{ lb per inch}$$

On the nomogram, project from w_t = 2020 through A_m = 18.6 to the unmarked scale. From this point, project a line through 2, as labeled on the *bevel* side of the N/n scale, to the s scale. For a 14½-deg pressure angle, s = 76,000 psi; for a 20-deg form, s = 66,000 psi.



Nomogram for determining surface compressive stress in 14½ and 20-deg straight-tooth spur and right-angle bevel gear teeth

Design Factors for Stress Concentration

Flat Bars with Multiple Notches

By A. J. Durelli, R. L. Lake and E. A. Phillips

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STRESS concentrations caused by single fillets, holes, and notches are well known,[1, 2] but less information is available for multiple discontinuities, such as two or more grooves in a shaft, holes in a plate, or notches in a bar. One form of the latter case, semicircular notches in a bar under axial load, has been investigated[3] and is discussed in this article. Of particular interest to designers is the "stress-relieving" characteristic of multiple notches.

Some of the bar conditions to which this article applies are shown in *Figs*. 1 to 4. Stress-concentration factors introduced by the notch or notches, *Figs*. 2 to 4, apply to brittle materials under static or dynamic loading and to ductile materials under fatigue loading. For example, in machine parts, structural members and airplane construction, notches may be necessary in tension or compression members to permit passage of a cross member, such as a cable or bar passing perpendicularly to the notched bar. Data in this article would serve in such cases to establish the stress-concentration factor, *K*, and aid in modification of the part for more strength.

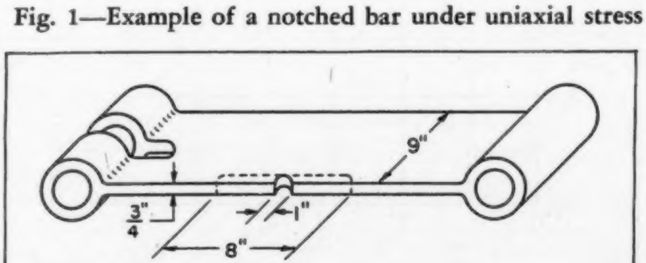
Stress-concentration values for one to five semicircular notches and for the flat-bottom notch with circular fillets are shown in *Fig*. 2. Stress concentration factor, *K*, as used in this article is defined as the ratio of the maximum stress in the bar to the average stress at the gross area (unnotched section).

Results were established photoelastically with a standard bar-width to notch-radius ratio, $W/r = 18$. This value was selected as a compromise between the more desirable semi-infinite plate ($W/r \rightarrow \infty$) and the space limitations of the experiment. This ratio was varied in one case: two notches, spaced at a center-to-center distance of two notch diameters, *Fig*. 3. From this curve, it is seen that the effect with a ratio of 18 closely approximates that for the semi-infinite plate. For one notch this approximation is even better but, for three or more notches, the large amount of bending present over the cross-section containing the notches makes necessary a larger plate-width to notch-radius ratio if the same degree of approximation is to be attained.

As shown in *Fig*. 2, any case of multiple or flat-bottom notches is characterized by lower concentration values than the single notch. This phenomenon makes possible increased strength through reduction in weight. More specifically, any notch added to one or more already existing in a given overall space decreases the stress concentration with the flat-bottom notch acting as a limiting case.

If the data in *Fig*. 2 are replotted with the center-to-center distance between notches used as the abscissa, *Fig*. 4, it becomes evident that a continuous addition of notches at the same pitch also causes a continuous decrease in the stress-concentration factor. The lowest values occur with $l/D = 1$, i.e., with the notches touching. As l/D becomes large, the notches

Fig. 1—Example of a notched bar under uniaxial stress



[1] References are tabulated at end of article.

Data Sheet

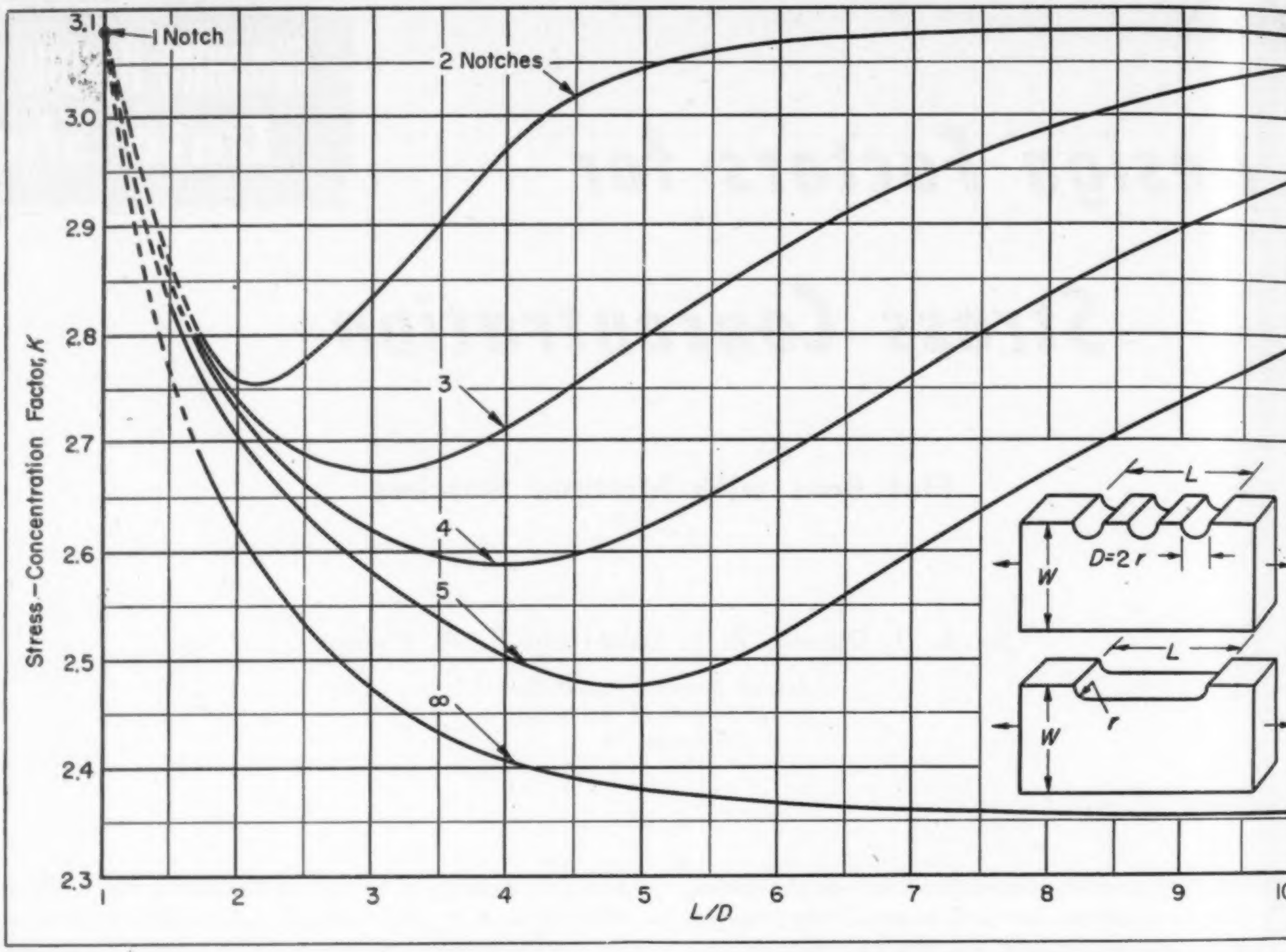
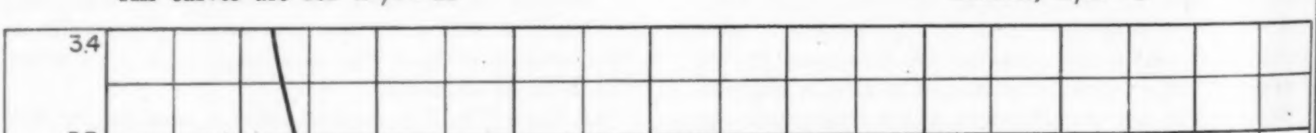


Fig. 2—Above—Stress-concentration factor, K, for axial loading of a bar with semicircular notches. All curves are for $W/r = 18$

Fig. 3—Below—Stress-concentration factor, K, for axial loading of a bar with two semicircular notches, $L/D = 3$



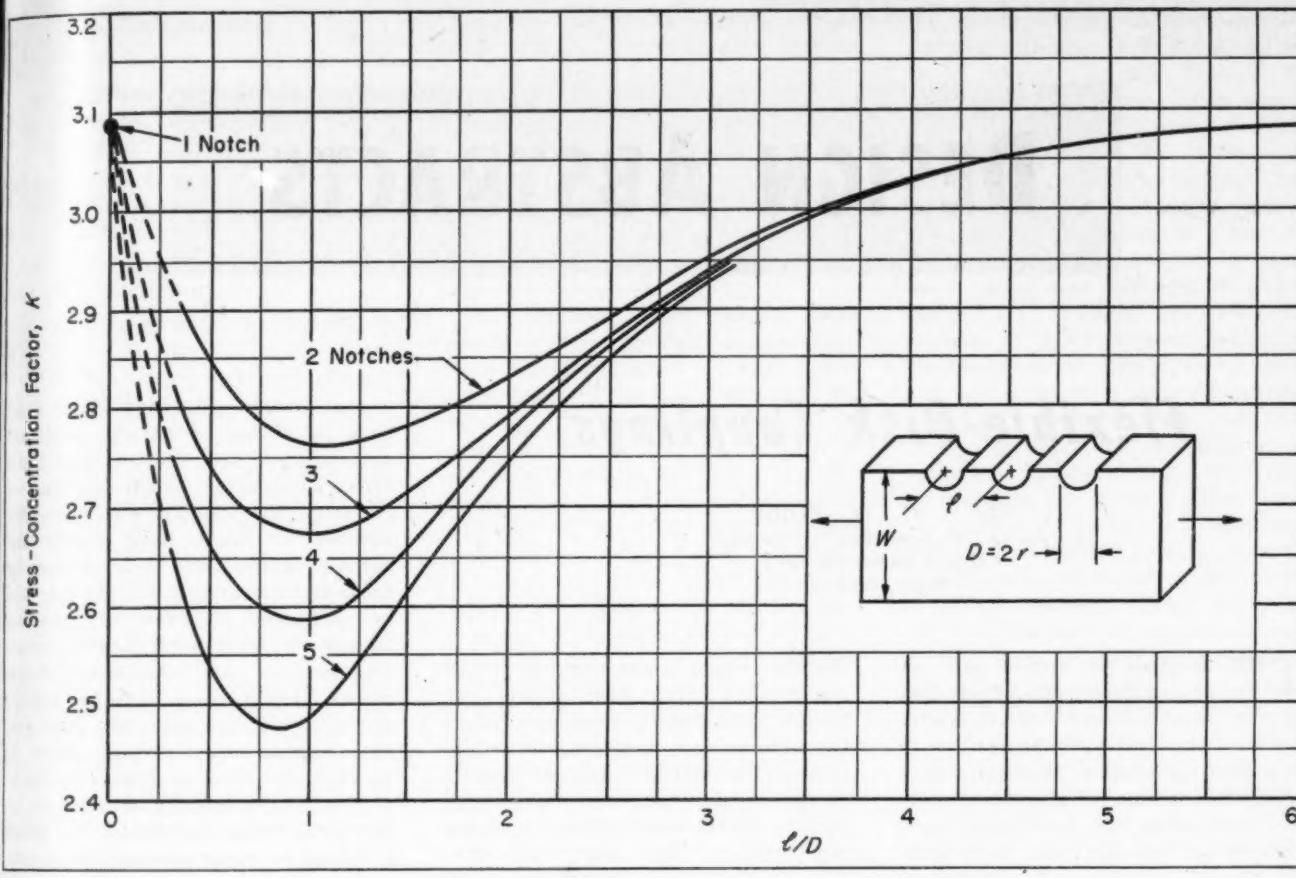


Fig. 4—Stress-concentration factor, *K*, for axial loading of a bar with semicircular notches. All curves are for $W/r = 18$

grow farther apart and the curves approach the value of 3.08 for the single notch.

In all cases the maximum stress in the bar occurs at the exterior notch. Therefore, if a notch is supplemented by one or more adjacent notches, in the sense of stress relieving, the final exterior notches assume the higher stresses which, nevertheless, are lower than the original stresses around the single notch.

The effect of stress relieving can also be observed for grooves in a shaft under axial load or torsion.[4, 5] Also known is the stress-relieving effect of removing adjacent material, such as undercutting a nut or adding a groove near the end of the threaded section of a bolt.[5] Similarly, values of stress concentration calculated by Ling[6, 7] for two circular holes in a plate exhibit a nature similar to the two semicircular notches, and the stress reduction resulting from the use of two holes instead of one is of the same order of magnitude as that for the notches.

If curves of the type shown in *Fig.* 3 were available for every case—one to five notches at four to five different spacings—the designer would be able to read directly the values for any finite or small bar-width to notch-radius ratio. However, a great amount of work would be necessary to establish such curves. At present, anyone confronted with a small bar-width to notch-radius ratio should get reasonable results using *Figs.* 2 or 4 in conjunction with *Fig.* 3.

EXAMPLE: Assume the material of the bracket shown in *Fig.* 1 to be a heat-treated steel with a tensile strength of 100,000 psi and yield point of 70,000 psi. The single notch, from *Fig.* 2, raises the maximum stress to a value 3.08 times the stress that would occur in the bar without the notch. If 25,000 psi is the maximum desired stress in the material, the allowable end load would be (25,000) (9) (0.75)/3.08 = 55,000 pounds. *Fig.* 2 can be used directly since $W/r = 9/0.5 = 18$. For smaller W/r ratios a larger stress-concentration value must be taken, such as suggested by *Fig.* 3. If the material on each side of the notch is removed so that an 8-inch flat-bottom notch is substituted for the original notch, $L/D = 8$ and, from *Fig.* 2, a concentration factor of 2.36 will exist, a reduction of (3.08-2.36)100/3.08 = 23 per cent. Thus, with the same load the bar can be made 23 per cent thinner, i.e., 0.75(0.77) = 0.58 inch. Or with the same 0.75 inch thickness, a 23 per cent larger load can be applied, 55,000/0.77 = 71,000 pounds.

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DESIGN ABSTRACTS

Flexible-Disk Couplings

By P. H. W. Wolff
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THE designer of almost any rotating machinery often finds that he has to provide for relative movement between various connected parts of a shafting system. Movement may arise from a number of causes: thermal expansions and distortions; nonrigidity of casings and bedplates; machining errors and tolerances. Even the sag, under its own weight, of a long, heavy shaft may necessitate a special coupling to avoid excessive bearing loads and shaft stresses, or to achieve the satisfactory operation of a gear-box. One coupling which seems particularly attractive for high shaft-speeds and torque throughputs, especially where the surrounding parts are hot or lubrication is difficult, consists merely of one or two flat metal disks which provide for the misalignment by bending between their hubs and rims.

In general terms, the designer is required to select or design a coupling, for a given shaft speed and power transmission, which will safely accommodate a certain relative shaft movement. This relative movement may, according to the application, consist of axial approach of the shaft ends, or tilting or parallel sideways movement of the shaft center lines. When considering a disk coupling for the duty, the designer can choose the number of disks, their inside and outside diameters, their shape of cross-section and the material, and he will need to know the stresses caused by centrifugal action, torque transmission, and the shaft movements. There may also be special stiffness requirements. For example, the coupling may, perhaps, have to be very soft because of bearing loads, or possibly, relatively stiff to transmit some small end thrust for which it would be expensive and inconvenient to provide a separate thrust-block. Since one disk, or a pair of disks close together, will behave very nearly as a universal pin-joint, two couplings separated by a length of "floating" shaft will be required when relative, parallel, sideways

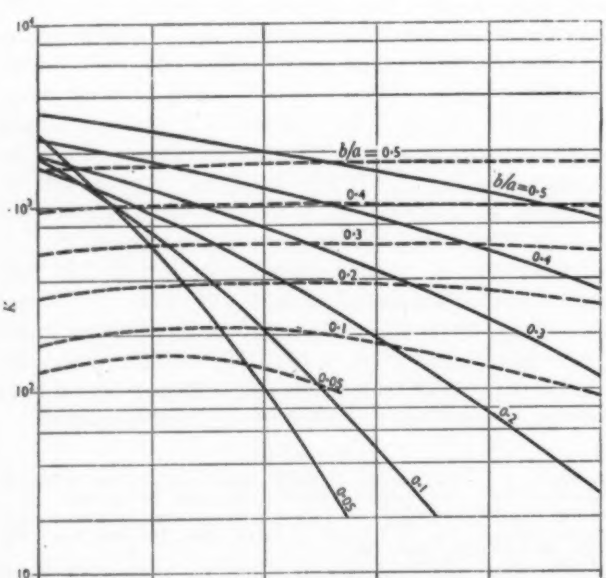


Fig. 1—Above—Effect of taper on hub and rim bending stresses for skew deflection. Dashed curves represent rim stress; solid, hub stress. Stress $p_r = Kt_b/a$ tons per sq in. per deg of skew

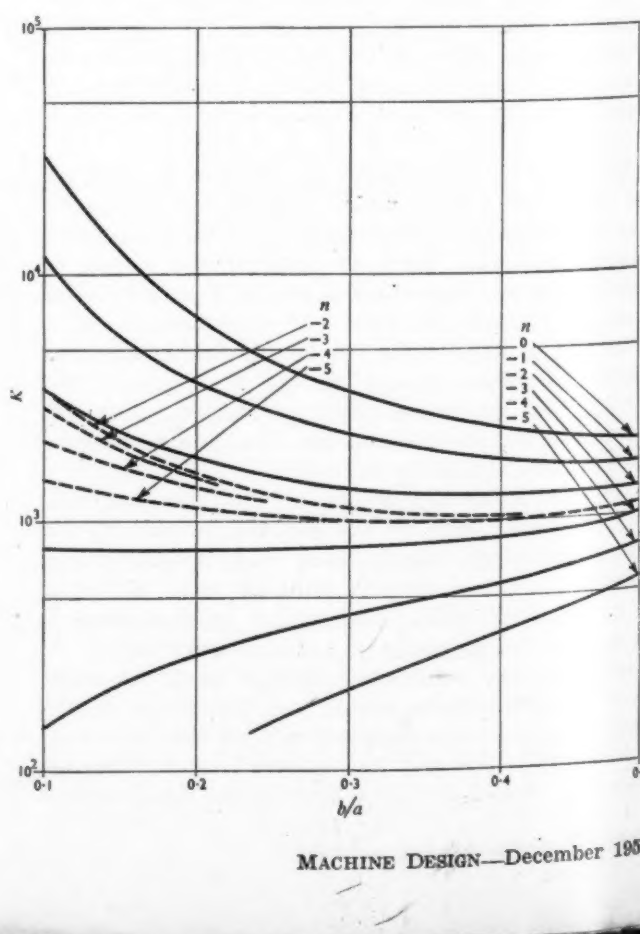


Fig. 2—Right—Hub and rim bending stresses for skew bending in terms of torque throughput and shear stress. Dashed curves represent rim stress; solid, hub stress. Stress $p_r = KT/qa^3$ tons per sq in. per deg of skew

Nomenclature

a = Outside radius of disk,* inches; as a subscript denotes "at rim"

b = Inside radius* of disk, inches; as a subscript denotes "at hub"

D = Flexural rigidity, $Et^2/12(1 - \sigma^2)$, ton-inches†

E = Young's modulus, tons per sq in.†

K = Calculation factor for stress

k = Calculation factor for stiffness

n = Exponent of variation of flexural rigidity; that is, $D = D_b(r/b)^n$ and $t = t_b(r/b)^{n/3}$

p = Bending stress at disk surfaces, tons per sq in.†

q = Torque shear stress, tons per sq in.†

r = Radius, inches; as a subscript denotes "radial"

T = Torque throughput, ton-inches†

t = Local disk thickness, inches

θ = Angular position relative to datum; as a subscript denotes "tangential"

σ = Poisson's ratio (or $1/m$).

* Radii a and b refer to the "thin" part of the disk and do not include fillets and bolting.
† One English long ton = 2240 pounds.

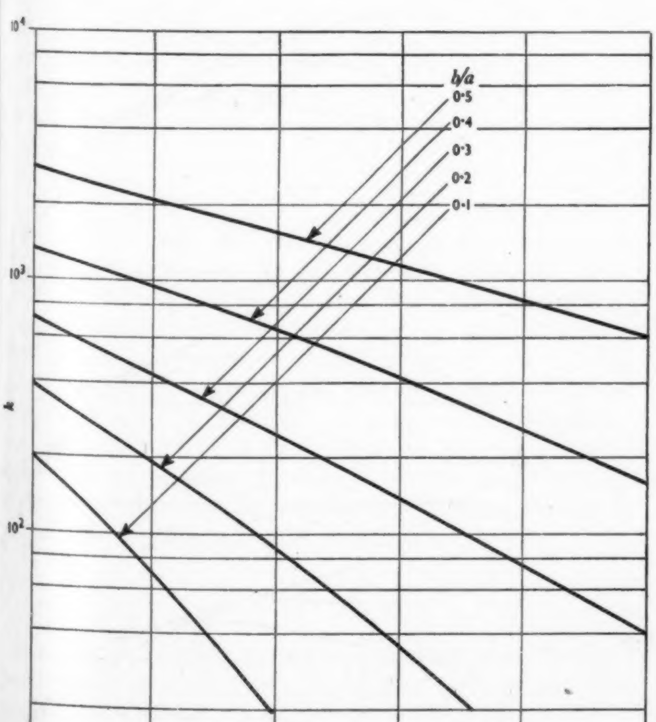
movement of the shafts is present. In this instance it may also be possible for the designer to decide the spacing of the couplings.

To achieve a satisfactory design, the designer needs to know the permissible stresses due to the various actions, and how the stresses in a coupling depend on the imposed deflections, the material properties and the disk dimensions.

The natural choice for the disks would be a ductile material—probably steel—and for such material there is a sharp distinction between the effects of steady and fluctuating stresses. With a coupling running at a steady speed the centrifugal stresses are steady, but relative tilting of the shafts causes bending stresses which reverse at each half-revolution of the shafts. The axial deflection and torque transmission stresses depend on the type of machine and the application, but these too are almost steady for turbine and electrical machinery. The normal design procedure for shafting is to consider only the major steady stresses in conjunction with large factors of safety, partly to account for stress concentrations and fluctuating stresses. The case of a disk coupling running with any appreciable skew misalignment, however, requires accurate determination of the maximum skewing stresses, and consideration of these in relation to the fatigue range of the material at the appropriate values of the steady stresses. A steel coupling running with absolutely steady stresses is unlikely to fail, even if the yield point is reached occasionally, but if the alternating stresses in the coupling, allowing for stress concentrations, exceed the fatigue limit, the coupling will fail eventually. It is important, therefore, to know the upper limit of the skewing to which the coupling may be subjected, and to design the coupling to have safe stresses at this maximum deflection.

Skewing of the disk produces radial and circumferential bending stresses at the hub and rim of the disk, and these, together with the complicated system of steady stresses, produce a combination for which a satisfactory comparison with the available simple fatigue data would appear to be difficult to obtain. For steel disks, however the relationship between the radial and circumferential bending stresses is such that generally no serious error arises in assuming the larger stress to be acting alone, and in addition, the fatigue range is relatively little affected by the simultaneous action of quite large steady stresses.

There are certain factors which tend to reduce the fatigue strength of the disk in relation to the laboratory estimation. Stress concentrations arise at the transition from the disk proper to the rim and hub. These stress concentrations can be reduced by providing generous transition fillets which, at their junction with the



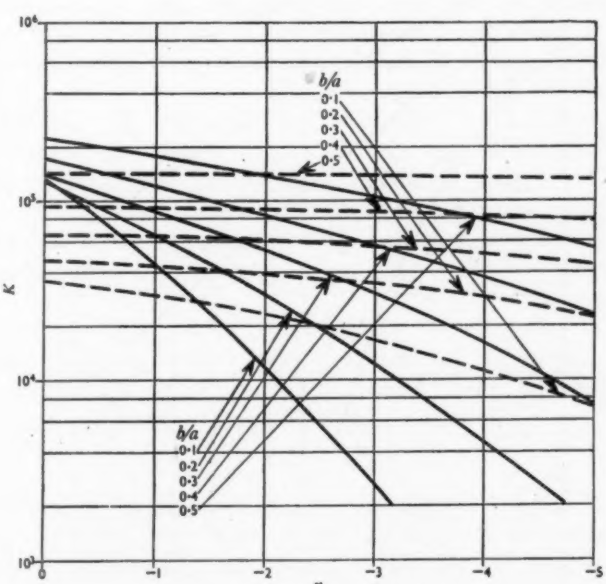


Fig. 3—Left—Effect of taper on stiffness for skew deflection. Stiffness = kt_b^3 ton-in. per deg of skew

Fig. 4—Above—Effect of taper on hub and rim bending stresses for axial deflection. Dashed curves represent rim stress; solid, hub stress. Stress $p_r = Kt_b/a^2$ tons per sq in. per in. movement

basic disk shape, have radii of curvature equal to several times the local disk thickness. Surface imperfections can considerably reduce the fatigue strength. If it is important to attain the maximum fatigue properties of the material, especially with high-tensile steels. Machining marks should be removed by grinding or stoning, and the disks polished. Corrosion adversely affects fatigue strength, particularly with high-tensile carbon steels, and if there is danger of corrosion, a stainless steel (or a suitable nonferrous alloy) should be used.

The results of the various stress calculations for steel disks are give in *Figs.* 1 to 6. The stresses hav been calculated on the basis of the usual thin disk assumptions. These are:

1. Small deflections only are considered, and stretch of the midplane of the disk is neglected
2. Straight lines in the disk which are normal to the midplane before bending remain straight after bending
3. Stresses normal to the midplane are neglected.

It is also assumed that the disk is provided with a relatively thick rim and hub for purpose of bolting up, that is, that the disk is encastered [edges clamped] at both rim and hub.

Only one form of disk taper has been considered, namely, that in which the disk thickness is proportional to some arbitrary power of the radius. With this form, only four elementary terms are involved in the deflection equation for both skew and umbrella deflections, whereas other forms would lead either to series solutions for the deflection, or to solution by step-by-step methods.

Shear and Centrifugal Stresses: The torque shear stress q is $T/2\pi r^2 t$. For the range of tapers covered by the curves, the shear stress is a maximum at the hub (q_{max}), and is $T/2\pi b^2 t_b$.

Centrifugal stresses are unlikely to be an important limitation on disk size except with high-speed shafts where, with reasonably light rim design, a maximum rim speed of about 450 ft per sec should prove satisfactory.

Effect of Material Properties: All the bending stresses and stiffnesses are directly proportional to Young's modulus. The curves have been plotted for a value of E of 13,400 tons per sq in. (30,000,000 psi).

Poisson's ratio (σ) has been given the value 0.3 for the curves. For the uniform thickness disk in both skew and umbrella bending, the stiffnesses, and the hub and rim radial bending stresses, are proportional to $1/(1-\sigma^2)$; and for both uniform thickness and tapered disks, at the hub and rim $p_o = \sigma p_r$.

Skew Bending: In *Fig.* 1, the radial bending stresses at the hub and rim are plotted in the form, $p_r = Kt_b/a$ tons per sq in. per deg of skew, against n and b/a. In comparison with the uniform thickness disk, taper decreases the maximum bending stress while the smaller rim-stress is relatively little affected. For a given hub thickness, taper decreases the mean thickness and hence the mean

(*Continued on Page* 219)

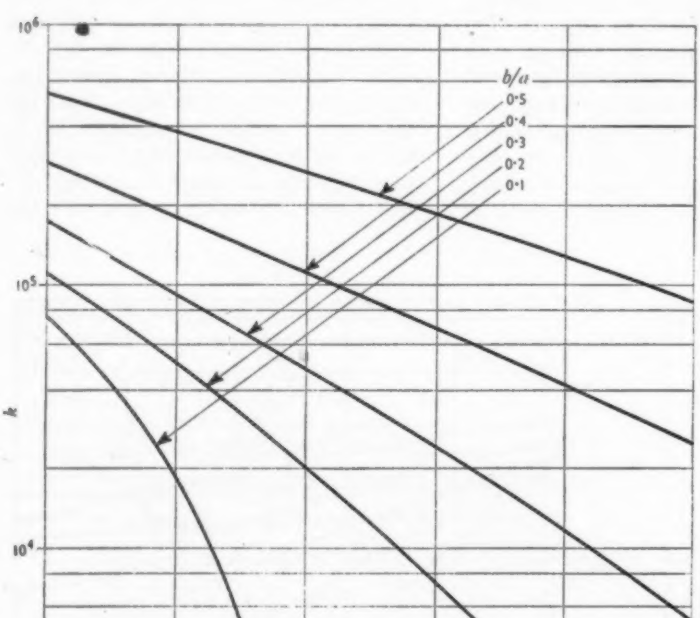


Fig. 5—Above—Effect of taper on stiffness for axial deflection. Stiffness = $kt_b{}^3/a^2$ tons per in. movement

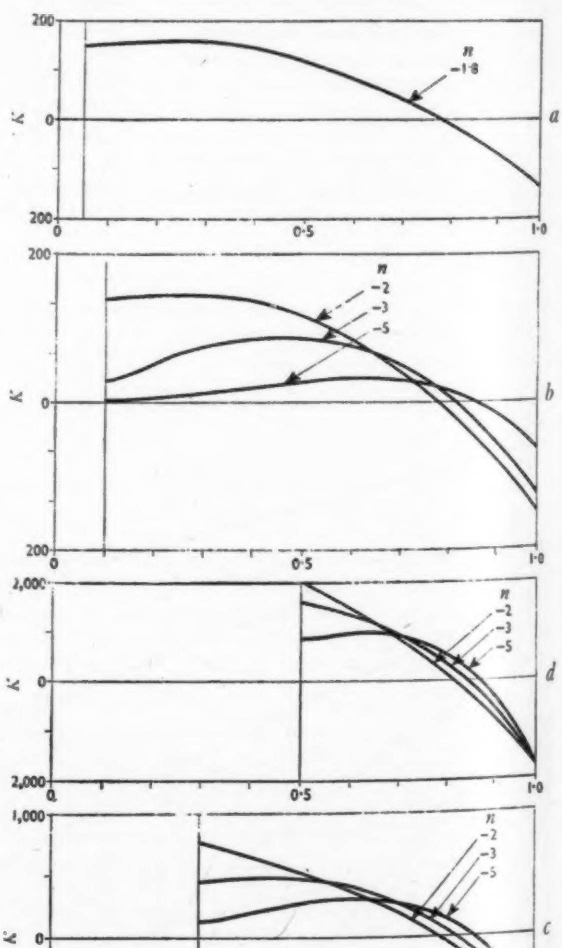


Fig. 6—Right—Distribution of radial bending stress for skew bending. At *a*, b/a = 0.05; *b*, 0.10; *c*, 0.30; *d*, 0.50. Stress = Kt_b/a tons per sq in. per deg of skew

MEN OF MACHINES

Appointment of **John C. Buckwalter** as chief engineer of the Long Beach division of Douglas Aircraft Co. Inc., Santa Monica, Calif., was announced recently. Mr. Buckwalter has been associated with Douglas since 1929. He was project engineer on the original DC-4 commercial transport and also helped design the B-19. From his position as executive engineer at the Santa Monica plant, he was advanced during World War II to the position of assistant manager and subsequently was made manager of the Chicago plant. For the past six years he has worked in the general office in Santa Monica as assistant to the engineering vice president. As chairman of the Industry and Education Advisory Board of the U. S. Air Force, Mr. Buckwalter has assisted the Air Force in establishing design and operating policies for the Arnold Engineering and Development Center recently dedicated at Tullahoma, Tenn. He is a member of the Society of Automotive Engineers.

John C. Buckwalter

♦

Frank A. Votta Jr. has been appointed chief engineer of the Hunter Spring Co., Lansdale, Pa. Associated with the company since 1941, Mr. Votta has been engineer in charge of design in the Neg'ator division for the past two and one-half years. He will now head engineering, design, and research activities in all phases of the company's operation except the Neg'ator division, and he will be responsible for engineering problems in the development of new manufacturing processes and the improvement of present equipment and techniques.

♦

Link-Belt Co., Chicago, has appointed **Bert L. Pearce** as chief engineer of the Ewart plant in Indianapolis, succeeding **Charles R. Weiss,** who has retired after 42 years' service. At the same time **Russell T. Sweeney** was appointed assistant chief engineer. Mr. Pearce has been associated with Link-Belt for 15 years and has held various positions in engineering and sales at the company's Dodge and Ewart plants. For the last ten months he has served as assistant chief engineer of product design. Mr. Sweeney came to the company in 1918 as a tool designer. Since last January he has been assistant chief engineer in application engineering at the Ewart plant.

♦

Westinghouse Electric Corp. has announced the appointment of **L. R. Ludwig** as director of engineering and research for the Atomic Power division, Pittsburgh. He succeeds **F. R. Benedict,** who is assuming new engineering responsibilities in the headquarters office. Since joining the company in 1925, Mr. Ludwig has served in various engineering and research capacities. He collaborated with another Westinghouse engineer in the discovery and commercial development of the ignitron rectifier, contributed to the field of protective devices such as lightning arresters and circuit breakers, and during World War II took part in work that led to the development of the atomic bomb.

♦

As a result of expanding research, Battelle Institute, Columbus, O., has promoted four members of its research staff to supervisory positions. **Dr. Horace J. Grover** has been named supervisor of research on fatigue and structural analysis; **Arthur D. Schwope,** supervisor of research in mechanical metallurgy; and **Henry A. Saller,** supervisor of research on special metallurgical materials. **Charles F. Lucks** will supervise the instrument division. At the same time, **Lloyd R. Jackson** was named an assistant director of the institute.

♦

W. Dawkins Espy, vice president of Lear Inc., Grand Rapids, Mich., has been named chief engineer for the company's Grand Rapids division.

♦

Johan A. Muller has joined the Lewis Welding & Engineering Corp., Bedford, O., as head of a newly formed development department. Holding more than 30 United States patents covering various phases of his work, Mr. Muller has specialized in the design and development of hydraulic equipment, particularly in its application to the plastics and rubber industry. For a number of years he served as chief engineer of the research and development laboratory of The Hydraulic Press Mfg. Co., Mt. Gilead, O., and later as a designer of special hydraulic equipment for Delco

Products division of General Motors Corp. at Dayton, O. Mr. Muller's new work will be chiefly concerned with the development of a plastic injection molding machine to which his company recently acquired all manufacturing and selling rights.

♦

Several promotions were announced recently in the Bendix Products division of Bendix Aviation Corp., South Bend, Ind. **George W. Pontius III** has been named manager of the automotive products section. **T. H. Thomas** replaces Mr. Pontius as manager of automotive engineering. **J. Allan MacLean,** former quality control manager, is now assistant manager of the aircraft products division, and **Frank C. Mock,** who was manager of fuel feed engineering, has been named director of all fuel system engineering.

♦

C. A. Norgren Co., Denver, has promoted **William O. Hall** to the position of chief project and test engineer. He will be in full charge of laboratory operations.

♦

Formerly chief engineer of Green Manufacturing Co., Racine, Wis., **E. H. Rocks** has been advanced to the position of vice president. He will retain charge of engineering in the company's metal working production, which includes stamped and fabricated parts, rolled forms, and polished, plated, or painted metal parts.

♦

Southwest Research Institute, San Antonio, Tex., has appointed **Trevor H. Clark** as director of the Division of Military Research and Development. He was also named as a special consultant to the Institute's Physics Department.

♦

William A. Williams, 316 East Wadsworth St., Philadelphia 19, Pa., recently resigned as chief engineer of the American Pulley Co. in order to devote his time to product development and consulting engineering. He was formerly a research engineer with the Westinghouse Electric Corp.

♦

Formerly professor of mechanical engineering at the University of Minnesota, **James J. Ryan** recently joined the staff of General Mills Aeronautical Research Laboratories in Minneapolis. He will serve as project engineer in the Electro-Mechanical Section. Mr. Ryan has been a technical consultant to Allis-Chalmers Mfg. Co., Federal Cartridge Corp., and Northwestern University.

♦

Several new appointments have been announced by the Armour Research Foundation in Chicago. **Dr. Gerhard A. Nothmann,** assistant chairman of the mechanism and propulsion research department, has been appointed department chairman. A specialist in dynamics and engineering mechanics, with particular interest in automatic machinery, vibrations, elasticity and the behavior of metals, Dr. Nothmann will supervise the activities of scientists, engineers and servicing personnel. Also promoted to chairman of his department, **Dr. Max Hansen** was formerly assistant chairman of the metals research department. He joined the Foundation in 1949 and was an associate professor of metallurgical engineering at Illinois Institute of Technology for two years. **Robert A. Lubker,** assistant chairman of the metals department, has been named an associate chairman.

♦

Frank W. Chambers has been appointed director of engineering of Kennecott Copper Corp., New York.

♦

Chester W. Bruce has been appointed chief engineer for the Chicago district of Republic Steel Corp., succeeding **Alvin A. Claassen,** who has retired. **Harold E. Berg** has replaced Mr. Bruce as assistant chief engineer.

♦

Raymond S. Perry has been elected vice president and director of Federal Telephone and Radio Corp., Clifton, N. J., manufacturing associate of the International Telephone and Telegraph Corp. He has had wide experience in both the sales and engineering fields of the communications industry.

♦

Paul Harter has been named chief project engineer of the industrial division of the Warner Electric Brake & Clutch Co., Beloit, Wis. Before joining the Warner organization in 1947, Mr. Harter served on the engineering staff of the Wright Aeronautical Corp.

♦

Kaiser-Frazer Corp., Willow Run, Mich., has appointed **R. L. Logue** and **D. H. Tillotson** to the positions of chief body engineer and chief engine and chassis engineer, respectively. Mr. Logue has been production engineer and Mr. Tillotson, chief draftsman.

♦

E. G. Shower, formerly a member of the technical staff of the Bell Telephone Laboratories, has joined Radio Receptor Co. Inc., Brooklyn, N. Y., as chief engineer of the newly formed Germanium division. He will be in charge of development and production activities concerning germanium and devices using germanium.

♦

Former manager of the engine division, **J. B. Waskey** has been appointed assistant to the vice president in charge of production at Pacific Airmotive Corp., Burbank, Calif. **L. B. Littrell,** formerly manager of the aircraft division, succeeds Mr. Waskey and has additional duties as jet project engineer.

♦

Frank W. Curtis has been appointed vice president and chief engineer of Crescent Metal Products Inc., Cleveland. He comes to this company from the Aluminum Co. of America.

♦

Rudolph J. Lesnik has been appointed chief engineer of the Gorham Tool Co., Detroit. He has been associated with the company since 1942.

NEW PARTS

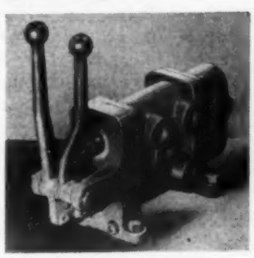
AND MATERIALS

. . . presented in quick-reference data sheet form for the convenience of the reader. For additional information on these new developments, see Page 189

HYDRAULIC CONTROL VALVE — 1

. . . offers one-hand multiple operation

American Industries Co., Dept. 6, Bristol, Pa.



Control levers can be operated independently or simultaneously.

Designation: Model B.

Size: 6 to 10 gpm.

Service: Actuating 2 single-acting lifting cylinders or 1 double-acting cylinder; working pressures to 1500 psi.

Design: Spool and sleeve type, combination 3 and 4-way with built-in relief valve; spring-centered; hardened, precision-ground spools operating in hardened steel sleeves; hardened pivot pins.

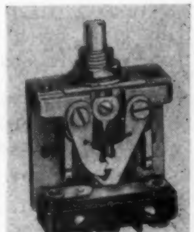
Application: Farm and road machinery; machine tools; aircraft; hydraulic presses.

For more data circle MD 1, Page 189

MAINTAINED-POSITION SWITCH — 2

. . . closes on first push, opens on second

General Control Co., Boston 34, Mass.



Fast switching is permitted by the spring-operated return action of the operating plunger mechanism.

Designation: A-C-O.

Size: 2 25/32 in. high, 2 in. wide, 1 1/32 in. deep.

Service: As transfer, safety or limit switch; contacts rated 20 amp, 125 v a-c, noninductive; first press transfers the contacts and second press restores them.

Design: Single-pole, double-throw, for either normally closed or open circuits; operating-plunger mechanism is insulated from the contacts; wide-spaced terminals with barriers; supplied with dust cover; mounting either through single hole by means of ½-in. threaded buching, or top or side-panel mounting with clearance holes for 6-32 screws.

For more data circle MD 2, Page 189

SOLENOID — 3

. . . designed for quiet operation

National Acme Co., 170 *E.* 131*st St., Cleveland* 8, *O.*

Plunger impact is cushioned, for use where the plunger is subject to a severe return blow in operation under a spring load.

Designation: 3K-300.

Size: ¼, 5/16, ⅜, 1½ in. strokes.

Service: Push or pull, 2½ to 14 lb, in approximately 1-lb increments; noise is reduced by cushioning plunger impact; for 110, 220, 440, 550 v, 25, 40, 50, 60 cycle a-c; d-c, special; can be furnished for up to 400 strokes per min.

Design: Leather-faced retainer stop and hood acts as guide and silencer for plunger; plunger laminations are bonded with Stellite at sides and point of impact; base or side-mounted; hand-wound copper coil insulated with 3-ply varnished cambric, and impregnated and varnished cord; Bakelite spool ends; steel coil liner.

For more data circle MD 3, Page 189

ANCHOR NUT — 4

. . . of self-locking, spring-steel construction

Kaynar Mfg. Co. Inc., 820 *E.* 16*th St., Los Angeles, Calif.*

This stamped anchor nut is simple in design and exceptionally light.

Size: ¼-in. presently available; No. 8 to ⅜-in. available in near future.

Service: Crimped flexible threaded portion grips bolt, providing uniform locking torque for large variations in bolt diameter; threads are hard and wear-proof; locking torque not altered by number of insertions and removals; high-temperature applications to 700 F; has static axial load strength above Army and Navy requirements.

Design: Solid or floating anchor, or gang-channel type; flanged anchoring portion is integral with thin-walled drawn spring-steel shell, fully tapped throughout length; high-carbon annealed spring-steel shell is crimped, then heat-treated to provide flexible gripping action.

For more data circle MD 4, Page 189

NEW PARTS AND MATERIALS

KEY-OPERATED SWITCHES 5

... restrict use to authorized personnel

Square D Co., 4041 *N. Richards St., Milwaukee* 12, *Wis.*

Every possible combination of key withdrawal (locking) positions is available.

Designation: Class 9001, type TSK.

Size: $1\frac{5}{8}$ in. wide, $1\frac{1}{2}$ in. high, $1\frac{9}{16}$ in. deep to mounting plate.

Service: Selector switching with key withdrawal in one, two or three positions; oil-tight; two keys furnished; keys operate any standard unit—special combinations can be furnished; maximum ratings as follows:

Alternating Current			Direct Current	
Volts	Amperes (normal)	Amperes (inrush)	Volts	Amperes (normal)
110-125	6.0	60	115-125	2.2
220-250	3.0	30	230-250	0.55
440-480	1.5	15	550-600	0.2
550-600	1.2	12		

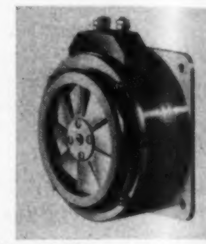
Design: 2 or 3-position switches with SPDT, DPDT, DPNC or DPNO contacts at 1 position on 2-position switches, at 1 or 2 positions on 3-position switches; interchangeable legend plates, standard or special.

For more data circle MD 5, Page 189

SMALL MOTOR 7

... maintains exact synchronous speed

Allis-Chalmers Mfg. Co., Milwaukee 1, *Wis.*



On starting or after transient voltage drop or overload, this motor will immediately pull into step at the rated frequency.

Size: 4 in. diam, $2\frac{3}{8}$ in. long; weight, 2.6 lb.

Service: Develops 8 oz-in. starting torque, 0.8-oz-in. synchronous torque; operates at synchronous speed; reversible; speed ranges up to 40 to 1; continuous operation on voltages up to 250 v, frequencies from 10 to 400 cycles, single, 2 or 3-phase; can be used as generator in control and indicating systems.

Design: Reluctance type; can be furnished with 2, 4, 6, 10 or 12 poles for single or 2-phase operation, 2, 4, or 8 poles for 3-phase; no starting equipment needed; flange or special mounting.

Application: Sequence timing systems; high-speed instrument chart recorders; large electric clocks; speed and position control systems; signal generators in speed indicating, recording and control systems.

For more data circle MD 7, Page 189

ENAMEL COATED STRIP 6

... in any desired color or shade

Coated Coil Corp., 501 *W.* 30*th St., New York, N. Y.*

Flexibility and adhesion of the baked-enamel coating, plus a special binding process, enable this strip stock to be used for stamped, formed and drawn parts.

Designation: Enamelstrip.

Size: Width, $\frac{1}{32}$ to 30 in.; thickness 0.006 to 0.040-in.; coiled to length desired.

Service: Prefinished stock for stamping, drawing, forming, fabricating; dry film thickness, 0.0001 to 0.001-in., special to 0.002-in. for government specifications; withstands manufacturing stresses and bends to 180 deg without cracking or peeling; maintains finish through manufacturing operations.

Design: Cold-rolled steel, electrogalvanized steel, electrolytic tin plate, brass, zinc or aluminum strip; chemically treated, then finished on one or both sides with synthetic enamel (alkyds, ureas, phenolics, etc.); colors and shades to specifications, with first side in one color, second in another if desired; acid, temperature-resistant and weatherproof finishes available; finish is baked on and coil slit to exact width desired.

Application: Automobile parts, appliances, containers, office equipment, instrument parts, batteries, toys.

For more data circle MD 6, Page 189

BIMETAL THERMOSTATS 8

... hermetically sealed with neoprene

Stevens Mfg. Co. Inc., 69 *S. Walnut St., Mansfield, O.*

Contacts, terminals and leads are protected from moisture and contaminants.

Designation: MH 100, 200, 300; CH 100.

Size: Can size—MH 100, CH 100, $\frac{49}{64}$-in. long, 0.750-in. wide, 0.345-in. thick; MH 200, $1\pm\frac{1}{32}$ in. high, $\frac{15}{16}$-in. diam; MH 300, $1\frac{1}{2}$ in. long, $1\frac{1}{64}$ in. wide, 0.440-in. thick; 12-in. leads.

Service: Temperature control from −76 F to +250 F for neoprene, −76 to +400 F for silicone-rubber; hermetically sealed against moisture and contaminants; electrically independent bimetal thermal element eliminates artificial cycling; factory calibrated:

Operating Voltage	Amperes CH	Amperes MH (Std.)	Amperes MH (Spec.)
6-30 v d-c	5	10	20
50 v d-c		5	5
125 v a-c, 40 c*	5	8	20
250 v a-c, 40 c*	2	4	4
125 v a-c, 25 c	4	6.5	6.5
250 v a-c, 25 c	1.5	3.2	3.2

* and up.

Design: CH is low-wattage bimetal strip unit, MH is bimetal disk; MH and CH 100 are sealed in type CR-7 crystal can with neoprene or silicone rubber molded over terminals and leads; MH 200 is round metal can with molded top; MH 300 has molded rubber enclosure; silver contacts; stainless or Inconel return spring; base, Alsimag or equal.

For more data circle MD 8, Page 189

JOHNSON BRONZE

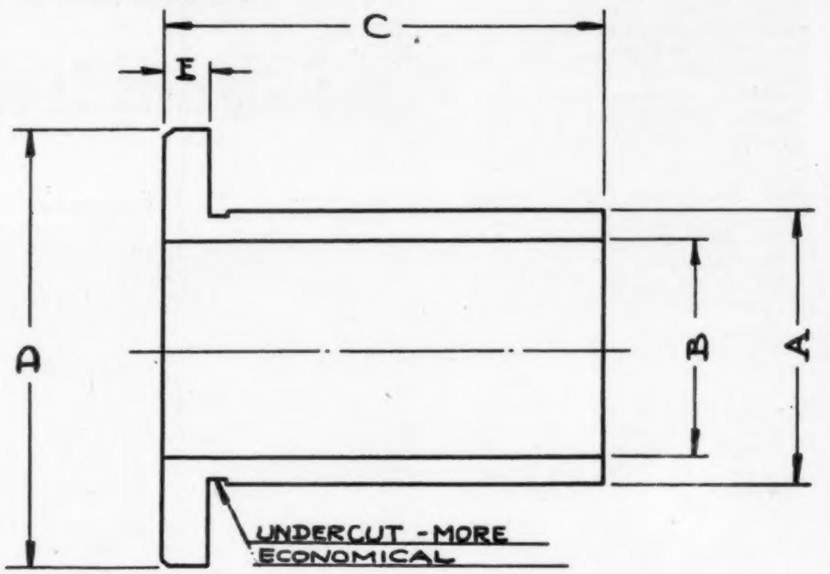
SLEEVE BEARING DATA

Bearing DESIGN

JOHNSON BRONZE

SLEEVE BEARING DATA

Flanged Sleeve Bearings



Measurements to specify when ordering Flanged Bearings.

THE addition of a flange on a sleeve bearing often serves as a very useful device to the designer. For instance it is an ideal way of meeting the problem of end thrust. Or it can serve to locate or anchor the bearing; to act as a divider; or to form a recess to hold the lubricant. In some cases, particularly in electric motor bearings, the flange has a beveled edge to insure alignment.

In cast bronze bearings the flange can be located anywhere on the outside diameter and can be made any thickness as required. In sheet metal bearings the location of the flange is limited to the ends and cannot be any thicker than the metal used in the body of the bearing.

In applications where the principal use of a flange is to meet a thrust condition it is well to include oil grooves on the face of the flange. In cast bronze the most popular type is the wedge shape as illustrated herewith. This permits the introduction of oil in order to produce the hydraulic pressure required to separate the flat surfaces. Sheet metal bearings usually employ a design known as "tear drop."

In applications where the operating speed is comparatively slow, it is often wise to use graphite impregnated bearings. The graphite can be included on both the inside diameter and the flange of the bearing. In some cases it is often difficult or impossible to locate the oil intake in the proper place to insure good lubrication while at the same time make it convenient and accessible. The use of flange in applications of this nature provides a reservoir for the lubricant. The oil intake can be placed in the most convenient place on the housing while the corresponding hole in the bearing can be placed where operating conditions demand.

Recommended type of groove on face of flange.

Powder Metallurgy

When the application permits, the most economical method of producing flanged bearings is by Johnson LEDALOYL. With this method the complete bearing is formed, under pressure, to required size and tolerance. All machine work is eliminated and you gain the advantage of the self-lubricating action. Many sizes of LEDALOYL flanged bearings are standard stock items, ready for immediate delivery. Our new catalogue gives a complete listing of sizes available. Write for your copy.

How to order Flanged Bearings

When ordering or specifying flanged bearing it is important that *all* dimensions are given. This diagram can be used as a guide. When using flanged half bearings be sure to specify whether they are FULL halves or SAW CUT. Saw Cut bearings can be used where shims are included. Full cut bearings are more expensive but are necessary for precision fits. The use of an undercut under the flange lowers production costs but does not interfere with the efficient operation of the bearing.

A. Outside diameter of bearing.
B. Inside diameter of bearing.
C. Length—over-all—of bearing.
D. Outside diameter of flange.
E. Thickness of Flange.

Engineering Service

Johnson Bronze offers manufacturers of all types of equipment a complete engineering and metallurgical service. We can help you determine the exact type of bearing that will give you the greatest amount of service for the longest period of time. We can show you how to design your bearings so that they can be produced in the most economical manner. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts free from prejudice. Why not take full advantage of this free service?

•

This bearing sheet data is but one of a series. You can get the complete set by writing to—

Johnson Bronze

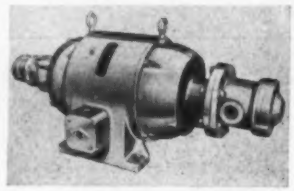
SLEEVE BEARING HEADQUARTERS
525 S. MILL ST. • NEW CASTLE, PENNA.

NEW PARTS AND MATERIALS

FLANGE-ENDBELL MOTORS — 9

. . . for direct mounting of hydraulic pumps

Reuland Electric Co., Alhambra, Calif.



Endbell flanges of these motors are machined to fit most standard pumps, insuring precision alignment between pump and motor shafts.

Size: 9 in. diam flange with 6 equally spaced 11/32 in. holes on 3 11/16 in. radius for NEMA frame sizes 224, 225, 254, 284, 324, 326 (shown on right endbell); 2½ in. square flange with 4 equally spaced ⅜-16 tapped holes on 2½ in. radius for same NEMA frame sizes plus 204 (shown on left endbell).

Service: Motors available from ¾ to 20 hp; reduces pump wear by eliminating misalignment between pump and motor.

Design: Flanges under *Size* fit most standard pumps; adapters or special mountings available for others; standard dripproof motor has pump flanges on one or both endbells; totally enclosed fan-cooled, or explosionproof, on one endbell only.

For more data circle MD 9, Page 189

GATE VALVES — 11

. . . made of forged steel for high pressures

R-P & C Valve Div., American Chain & Cable Co. Inc., Reading, Pa.

These general-purpose valves are small in size—the ½-in. size measuring 3 in. face-to-face and 5⅜ in. from center to top.

Designation: 6056 (screwed end); 6057 (socket-weld end).

Size: ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2-in. pipe size or tube OD size.

Service: Tested for 2500 lb hydrostatic pressure, 100 lb air test under water; 2-piece gland and follower provides uniform packing pressure; working pressures and temperatures as follows:

Temperature (F)	Pressure (psi)	Temperature (F)	Pressure (psi)
100	2000	600	1110
200	1820	700	940
300	1610	800	780
400	1460	900	600
500	1280	1000	380

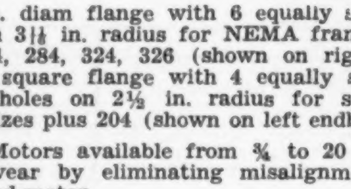
Design: Screw-over bonnet on ½, ⅜-in.; bolted bonnet with male-female joint on ½, ¾-in.; bolted bonnet with tongue-and-groove joint and soft iron gasket on rest; body and bonnet are forged carbon steel; gland bolts and nuts, chromium stainless steel; heat-treated, hard chrome-plated disk; solid wedge with pressed-in seat rings.

For more data circle MD 11, Page 189

CONVEYOR BELT CARRIERS — 10

. . . automatically correct sidewise shift

Stephens-Adamson Mfg. Co., Aurora, Ill.



These "training rollers" respond quickly to shift of the belt from dead center, moving to an angular position to return the belt to normal running conditions.

Designation: No. 720, 723—"Seal Master" normal-duty series; No. 214, 215—"Simplex" heavy-duty series; No. 234, 235—"Pacific" heavy-duty series.

Size: Nos. 720, 214, 234 have 6-in. diam rollers, others, 5-in.; No. 720, 723, for 16 to 60-in. width belts; 214 for 18 to 60-in.; 215 for 16 to 48-in.; 234 for 18 to 48-in.; 235 for 18 to 36-in.; other dimensions depend on belt width.

Service: Centering continuous conveyor belts; makes correction before belt has strayed more than fraction of an inch; minimizes edge wear of belt due to action of guide rollers; spaced at 50 to 100-ft intervals.

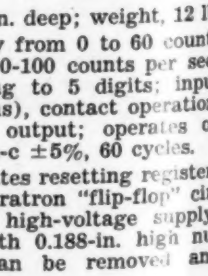
Design: Conveyor belt normally rides between actuating side-rollers; if belt strays, its weight presses down on side-roller, turning belt carrier to angular position with regard to belt travel; rotation of carrying rolls at angle to belt returns belt to normal position.

For more data circle MD 10, Page 189

IMPULSE COUNTER — 12

. . . for high-speed production operations

General Electric Co., Special Products Div., Schenectady 5, N. Y.



This step-motor counter is designed for counting ranges above those possible with electromechanical counters and below those requiring scaler counters.

Size: 13 in. high, 11 in. wide, 7 in. deep; weight, 12 lb.

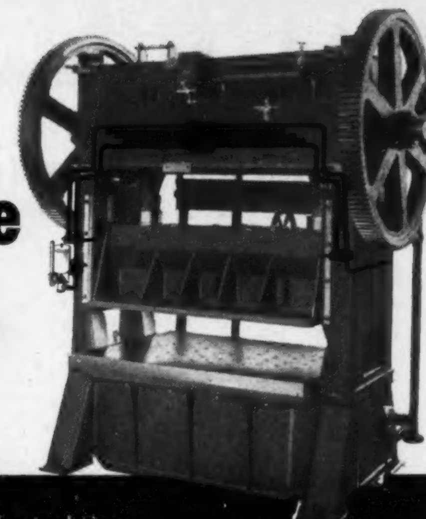
Service: 100% counting accuracy from 0 to 60 counts per sec; high accuracy from 60-100 counts per sec; random or continuous counting to 5 digits; input from voltage pulses (6-15 v rms), contact operation, or photoelectric preamplifier output; operates on + or − pulses; power, 115 v a-c ±5%, 60 cycles.

Design: 2-phase step motor operates resetting register; power supply consists of a thyratron "flip-flop" circuit, an input amplifier and high-voltage supply; manual-reset type register with 0.188-in. high numerals; counting assembly can be removed and placed at remote location.

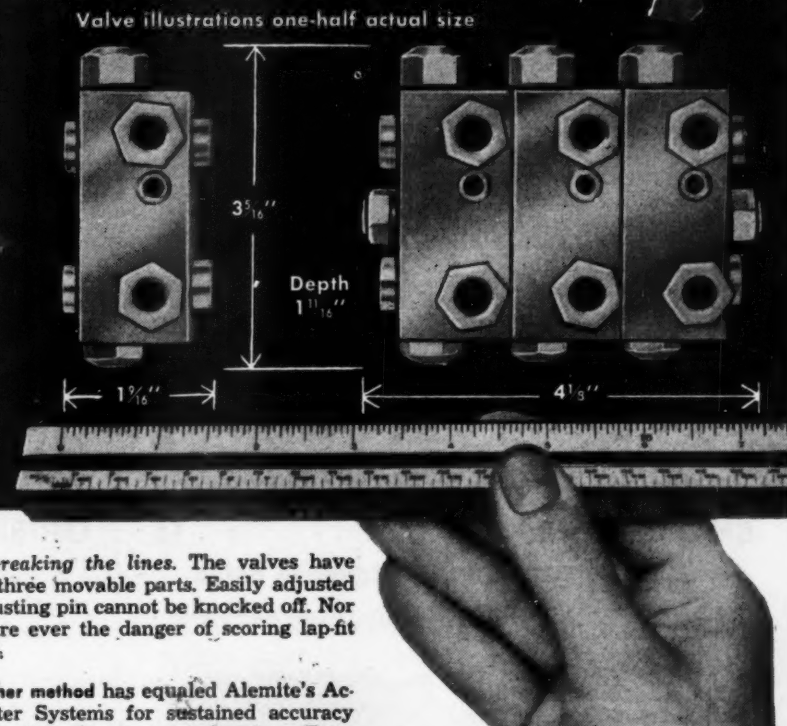
Application: Packaging machinery; textile machinery for counting flaws; radiation counting where direct reading desired.

For more data circle MD 12, Page 189

To help you...
design more production time into the heaviest machines



ALEMITE TYPE II Accumeter VALVES



Specially designed for tough-job lubrication . . . to enable you to *design in* greater production output on the largest, heaviest machines! Alemite's Type II Accumeter System extends the protection of automatic *mechanized* lubrication to mines, steel mills, processing plants everywhere. Gives you a *fully enclosed* system that can be used indoors or outdoors, can be painted or treated with anti-corrosives, and will handle every type of oil or grease that can be pumped—from fluid oils to heavy non-fibrous greases.

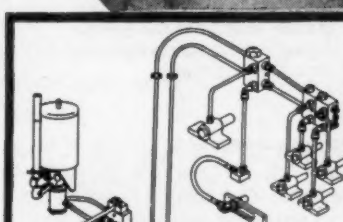
The Alemite Type II Accumeter Automatic Lubrication System consists of a lubricant pump, a distribution system of tubing, and *force-feed* valves mounted on or near individual bearings.

Automatically, from one central point, it safely, surely lubricates all the bearings on a machine—while production continues. Increases output by eliminating shut down for lubrication! Ends the risk of lubrication errors or neglect by your clients. Adds years to the life of the machine!

Unlike other systems, the valves on the Alemite Type II can be quickly serviced *without breaking the lines.* The valves have only three movable parts. Easily adjusted —adjusting pin cannot be knocked off. Nor is there ever the danger of scoring lap-fit metal.

No other method has equaled Alemite's Accumeter Systems for sustained accuracy in metering oil or grease to bearings. Tests show *no variation* in the amount of lubricant discharged to bearings . . . even after 73,312 lubrication cycles, equal to 122 years of twice-a-day service! Moreover, Alemite Accumeter Automatic Lubrication is not just "one-shot" lubrication. It is *continuous* between cycles. That's because Alemite's exclusive "accumulating" feature *prolongs* the discharge of lubricant to bearings.

To meet your full range of requirements, there are three different Alemite Accumeter Automatic Lubrication systems. Versatile in application, they are adaptable to machines of every type and size. Write now for Form 22-189, a free 16 page brochure giving full data. And for specific application recommendations, include description of machines you are now working on. Alemite, Dept. R-121, 1850 Diversey Parkway, Chicago 14, Illinois.



Alemite's Type II Accumeter System

Meters oil or grease to rotary, oscillating, stationary—plain or anti-friction bearings. Furnished in 4 capacities from .050 to .500 cu. in. All are adjustable. Single valves as well as manifolds of 2, 3, 4, and 5 are available. System handles up to 600 bearings. Manual or automatic operation.

ALEMITE

REG. U. S. PAT. OFF.

ACCUMETER AUTOMATIC LUBRICATION
1850 Diversey Parkway, Chicago 14, Illinois

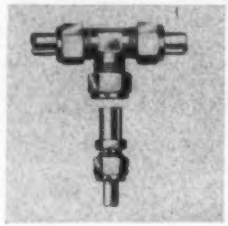
A PRODUCT OF SW STEWART WARNER

NEW PARTS AND MATERIALS

REDUCER FITTING 13

. . . holds heavy or thin-wall tubing

Crawford Fitting Co., 884 E. 140th St., Cleveland 10, Ohio



Permitting different tubing sizes to be joined easily, this fitting provides a torque-free and leakproof assembly.

Designation: Swagelok series R.

Size and Service: Joins two different tube sizes (OD, in.) 1/8 to 3/16, 1/8-1/4, 3/16-1/4, 1/4-3/8, 5/16-3/8, 3/8-1/2, 1/2-3/4, 5/8-3/4, 3/4-1, 7/8-1; fitting will withstand pressure exceeding tube bursting strength; torque not transmitted from fitting to tubing in assembly; heavy or thin-walled brass, aluminum, copper, steel, stainless steel, Monel or plastic tubing can be accommodated.

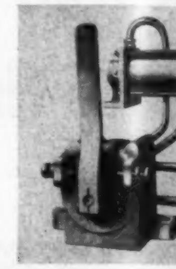
Design: Two ferrules are slightly swaged into tubing by threaded chuck, providing leakproof seals at 3 points; tubing is supported over entire length of assembly; available in brass, aluminum, steel, stainless steel or Monel.

For more data circle MD 13, Page 189

HYDRAULIC-CYLINDER VALVE 15

. . . controls direction and speed of travel

Wisler Engineering & Machine Co., Railroad & West St., Sturgis, Mich.



This compact valve eliminates the need for two extra speed-control valves.

Designation: Sincro.

Size: 1/4-3/8, 1/2 or 3/4 in. pipe sizes.

Service: Independent regulation of stroke-speed of double-acting cylinders from 0 to full valve capacity in both directions; 0 to 250 psi pressure; lever movement 70 deg, max; lever inclination indicates flow direction.

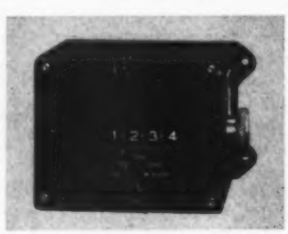
Design: 4-way, convertible to 3-way by plugging either of 2 cylinder ports; 3 models—hand-operated, foot-operated with rocker pedal, or foot-operated with spring return (no built-in speed control); oscillating disk and seat are ground and lapped to provide leakproof seal; valve stems sealed with O-rings; brass disk and shaft, iron body and lever for oil and air, others available.

For more data circle MD 15, Page 189

BATCH COUNTER 14

. . . closes switch on last count of batch

Production Instrument Co., 702-08 W. Jackson Blvd., Chicago 6, Ill.



Besides counting the number of batches, this instrument can also activate controls on packaging or materials-handling equipment.

Designation: WA.

Size: 5 3/4 in. long, 3 5/8 in. wide, 4 11/16 in. high.

Service: Counting preset batch quantities at up to 600 counts per min; counts any one or any combination of quantities within the following groups—(a) 5, 10, 50, 100, 500, 1000, 5000, 10,000—(b) 10, 25, 50—(c) 100, 250, 500—(d) 1000, 2500, 5000—(e) 2, 10, 20, 200, 1000, 2000, 10,000; at end of count, unit closes built-in batch control switch; counter actuation by switch, relay or photoelectric cell; furnished for 12 v 60 cycle, 24 v 60 cycle, 115 v 25, 40-50 or 60 cycle, 230 v 25, 40-50 or 60 cycle; also 6, 12, 24, 30, 48, 115, 150, 230 v d-c; special voltages available.

Design: Four number wheels; knob, key reset or non-reset types; dustproof cast-aluminum case; separate compartment houses wiring connections.

Application: Conveyors, chute gates, packaging equipment, pile changers.

For more data circle MD 14, Page 189

CENTRIFUGAL PUMP 16

. . . close-coupled and mechanically sealed

Economy Pumps Inc. Div., Hamilton-Thomas Corp., Hamilton, O.

Light in weight and easy to service, these general-purpose units are suitable for small pump applications.

Designation: SCC.

Size: 2 in. pipe inlet x 1 1/4 in. pipe outlet, overall size approx. 9 5/16 in. long, 11 in. wide, 18 in. high; 1 1/2 in. x 3/4 in., approx. 6 7/8 in. long, 8 in. wide, 15 in. high.

Service: General purpose; single or three-phase, 60 cycle current; operate at 3450 rpm; dismantled with 4 bolts; dynamically balanced impellers:

Motor (hp)	Max. Head: Head (ft)	Max. Head: Capacity (gal per min)	Min. Head: Head (ft)	Min. Head: Capacity (gal per min)
		2 x 1 1/4		
3	106	54	79	100
2	126	27	45	100
1 1/2	116	12	25	86
1	94	8	24	68
		1 1/2 x 3/4		
3/4	56	32	35	48
1/2	64	14	19	47
1/3	50	8	10	40

Design: Single-stage, vertical close-coupled; bronze fitted; mechanical seal; open type holding lugs; open dripproof induction motor; horizontal mounting special; cast-iron casing and motor stand.

For more data circle MD 16, Page 189

ADVERTISEMENT

POWDER METALLURGY CONSERVES MATERIALS

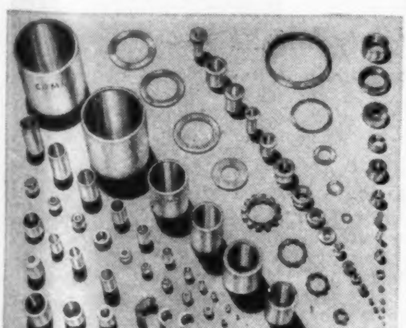
As the channeling of strategic metals into essential applications takes on increasing importance, the material-conserving advantages of powder metallurgy processes are receiving added attention.

In powder metallurgy, parts are die-formed to their final dimensions within extremely close tolerances. This does away with the need for machining operations which result in scrap metal.

Intricate Shapes

The advantages of the powder metallurgy process are of particular importance in the production of intricate structural shapes, which would normally involve extensive and complex machining, with a large amount of scrap. Gears, cams and many other parts are successfully produced, without machining, by the powder metallurgy process.

In addition to making most effective use of critical materials, the powder metallurgy process, by eliminating costly machining, reduces unit cost to the purchaser. Since the production of special shapes requires tooling, the low-



Parts such as these can be produced by the powder metallurgy process, without machining operations that result in metal scrap and increased unit costs.

cost advantage is most marked in high-volume work, where initial tooling charges are offset by subsequent savings in unit costs.

Compositions Available

Bearings and parts can be produced in any one of a number of compositions of "COMPO" (porous bronze) or "POWDIRON" (sintered iron) either with or without self-lubrication. Detailed information may be obtained from the manufacturer, Bound Brook Oil-Less Bearing Company, Bound Brook, N. J.

Strategic Materials S-T-R-E-T-C-H Farther

in "COMPO®" and "POWDIRON®"

BEARINGS AND PARTS

When hard-to-get metals are processed by Bound Brook powder metallurgy to form "COMPO" (porous bronze) and "POWDIRON" (sintered iron) bearings and parts, there's no waste of strategic materials. The metals go *farther*, to serve Bound Brook customers *better* — and to aid the defense program.

"COMPO" and "POWDIRON" bearings and parts need no machining, leave no scrap — at Bound Brook or on the user's assembly line.

For latest list of stock sizes of "COMPO" bearings, write us on your company letterhead. Consult our Engineering Department on parts and special bearings.

SEND FOR THIS FREE BOOKLET TODAY

BOUND BROOK

OIL-LESS BEARING COMPANY

BOUND BROOK, N. J. • BOUND BROOK 9-0441

"COMPO" • "POWDIRON" • "BOUND BROOK"

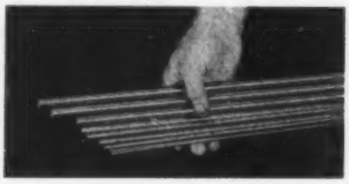
ESTABLISHED 1883

NEW PARTS AND MATERIALS

DRILL ROD 17

. . . in standard lengths

Ace Drill Corp., Adrian, Mich.



Harder than conventional tool-steel materials, these blanks have equivalent toughness.

Size: Available as hardened, tempered and centerless ground in $\frac{3}{16}$ to 1 in. diam, tolerance ±0.001-in.; or as hardened and tempered only, from 0.118 to 0.515-in.; length, 36 in.

Service: For knock-out pins, dowel pins or rollers; measure approximately 6 points higher on Rockwell *C* scale than conventional tool-steel materials.

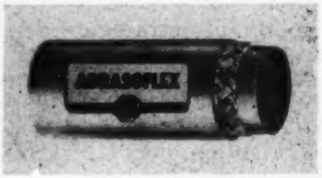
Design: 10-ft lengths of solid round bar stock are hardened, cut into blanks and centerless-ground.

For more data circle MD 17, Page 189

RUBBER HOSE 19

. . . for multiple-duty applications

Mercer Rubber Corp., 66 Reade St., New York, N. Y.



Smooth hose bore permits uninterrupted, fast flow, even when reeled.

Designation: Abrasoflex.

Size: 7 sizes from $\frac{3}{16}$ to 1 in. ID.

Service: For air, water, paint or oil spraying, grease or gasoline; working pressure to 250 psi; resists petroleum products and mild acids; resists abrasion.

Design: Rubber, with 1 or 2-braid, high-tensile rayon-reinforced body; black cover.

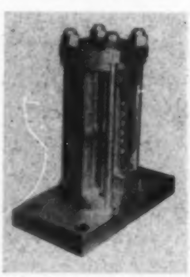
For more data circle MD 19, Page 189

VIBRATORS 18

. . . air-cushioned for quiet operation

Cannon Vibrator Co., 1111 Power Ave., Cleveland 14, O.

New principle of air-cushioning is claimed to eliminate bolt breakage and increase vibrator life.



Designation: EM.

Size: Piston diam, 1¼ to 5 in.; piston weight 1 to 45 lb; mounting bases, 6 to 18 in. long; total weight 12 to 240 lb.

Service: Vibration to prevent arching, hanging-up and sticking in bins, hoppers and chutes; air-cushioned action prevents metal-to-metal pounding, gives quiet operation, reduces strain on vibrator parts; effective pulsating and forwarding action is created by heavy pistons and extra-long strokes; operates on all pressures from 15 to 125 psi.

Design: Momentum and change in direction of piston creates vibration, with action air-cushioned at each end of stroke; bodies are hardened semisteel castings; steel pistons are heat-treated and electrolized.

For more data circle MD 18, Page 189

MASTER SWITCH 20

. . . for heavy-duty installations

General Electric Co., Control Dept., Schenectady 5, N. Y.

Designed for large materials-handling equipment, this switch features a new cast-aluminum cover and up to six adjustable stops.

Size: 14 in. high with handle vertical, 13 in. wide, 10 in. deep.

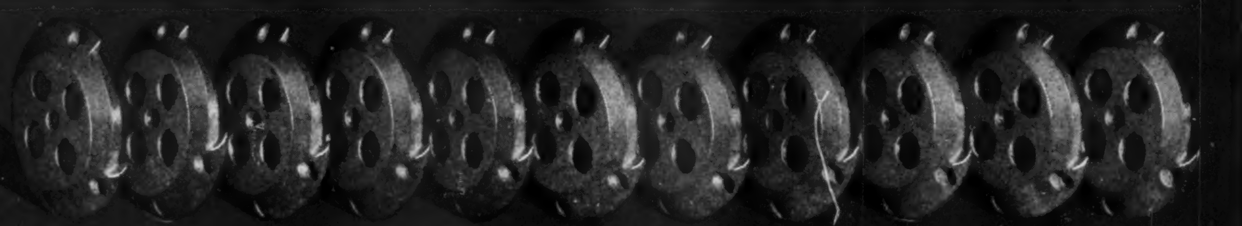
Service: Switching with one to six points of operating-handle movement in either clockwise or counter-clockwise direction, adjustable with open-end wrench; 6, 8 or 12 circuits; capacity, 15 amp, 600 v a-c or 1 amp, 250 v d-c; contacts replaceable without disturbing wiring; cover protects from dust, dirt and accidental blows.

Design: 3 frame sizes; light-weight cast-aluminum cover; ball-and-rod handle standard; same with off-position thumb-lever latch, auxiliary thumb-lever electric switch, spring-return mechanism, or under-lever mechanism also available; contacts identifiable by numbers on accessible terminal board.

Application: Materials-handling equipment; steel-mill cranes.

For more data circle MD 20, Page 189

SMALL DIFFICULT PARTS MADE EASY



Uniformity

The mass production of small, intricate parts often involves inspection problems almost equal to the production problems, plus the risk of scrap at each machining operation.

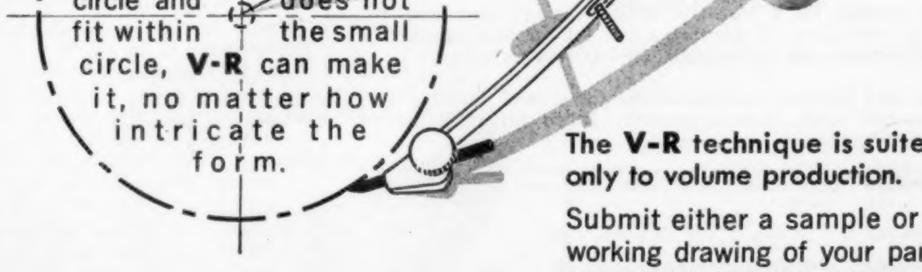
Uniformity is a basic characteristic of the **V-R** technique. A change from machining to our technique often results in the elimination of two out of three inspections.

Correct Design

Simple designs are best, but there is no longer any need to oversimplify for the sake of producibility.

The part whose design requires multiple machining operations, or whose service conditions require a non-machinable alloy can probably be made economically by the **V-R** technique.

In addition, **V-R** may be able to make the "impossible" part.



The V-R technique is suited only to volume production.

Submit either a sample or a working drawing of your part. We may be able to help you.

VASCOLOY-RAMET CORPORATION

DEPARTMENT M • WAUKEGAN, ILLINOIS

NEW PARTS AND MATERIALS

BRASS STRIP 21

... has brazed-in electric contacts

D. E. Makepeace Co., Attleboro, Mass.

Precious metal slugs, inserted in brass strip, act as contact points in stamped electric parts.

Form: Brass strip with brazed inserts; inserts are flat slugs brazed into strip, subsequently formed to contact shape.

Size: Strip, up to 6-in. wide, 1/16-in. thick; also stamped and formed parts to specifications.

Service: For parts requiring firm electric contacts.

Properties: Silver or other precious-metal contacts; composition of brass in strip supplied to individual specifications; insert contacts hard and wear-resistant due to cold working.

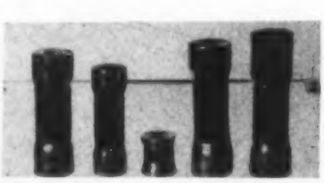
Application: Rotors or bridge contacts in switches.

For more data circle MD 21, Page 189

FLEXIBLE COUPLING 22

... for fractional-horsepower drives

Guardian Products Corp., 1215 *E. Second St., Michigan City, Ind.*



Available in a variety of bore sizes and lengths, these single-unit couplings are for applications using miniature and fractional-horse-power motors.

Size and Service: Compensates for minor angular and lateral shaft misalignments; three different series as follows:

—Rating (at 1750 rpm)—		——— Length ———		—Bore Sizes—
(watts)	(hp, approx)	(in., min)	(in., max)	(in.)
25-124	1/30-1/6	1	4	3/16, 1/4, 5/16, 3/8, 7/16, 1/2
125-248	1/6-1/3	1¾	7⅞	1/4, 5/16, 3/8, 7/16, 1/2, 9/16, 5/8, 3/4
249-550	1/3-3/4	2½	7⅞	7/16, 1/2, 9/16, 5/8, 3/4

Design: Single-unit construction; 2-4 ply rubber with synthetic reinforcement; 125-248 and 249-550 w series are also available with splined bores in 3-in. min lengths; die-cast zinc-alloy ends drilled and tapped for 5/16-18 socket set screw.

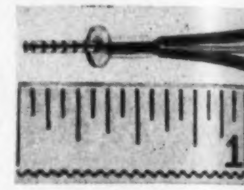
Application: Fluid pumps and compressors; appliances; blowers; power lawn mowers; machine tools.

For more data circle MD 22, Page 189

MINIATURE SLIP RINGS 23

... electroplated on one-piece dielectric core

Electro Tec Corp., South Hackensack, N. J.



Claimed to be far smaller than any previous type, these miniature slip rings have high dimensional acacuracy.

Size: 0.045-in. diam; 2 to 6 rings, 0.030-in. wide with barrier width, 0.015-in.; weight of 6-ring unit, 5.5 grains.

Service: As rotating contacts on miniaturized equipment; withstand 1000-v hipot test, ring-to-ring and between leads; dimensional accuracy assured by precision machining and polishing; precious-metal surface deposits prevent tarnish, minimize wear and brush noise.

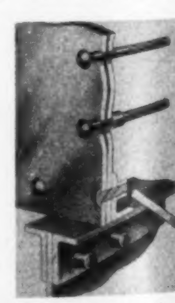
Design: Fine silver (hardness, 60 to 70 Brinell) rings, with palladium and rhodium or gold surface deposits, are electroplated into grooves of one-piece plastic-dielectric core; separate color-coded lead feeds each ring.

For more data circle MD 23, Page 189

TWO-PIECE FASTENER 24

... installed rapidly with pneumatic tool

Cherry Rivet Co., 231 *Winston St., Los Angeles* 13, *Calif.*



On installation, the fastener clamps the material being fastened tightly together, and clinches it under tension.

Designation: Lock Bolts; aircraft series; commercial series.

Size: 3/16 to 3/8-in. diam; grip lengths; 1/8 to 1 11/16 in.

Service: Fastening with strength values equal to or exceeding same-sized AN bolts; hole tolerances for interference fit exceed those of AN bolts, eliminating reaming; after installation, lock bolts weigh 50% as much as equal-sized bolts and nuts; clamping action will pull together a gap of ¼-in.

Design: Pin is inserted in work from one side; collar inserted on pin from the other; a special pneumatic tool engages the serrated grooves in the pin shank and exerts a pulling action on the pin; tool simultaneously pushes collar against material, thus clamping the material, then swages collar into pin grooves and breaks pin flush with collar; aircraft series in 75ST aluminum alloy or heat-treated alloy steel; commercial series in 24ST aluminum or mild steel; various head styles available.

For more data circle MD 24, Page 189

HOW TO MAKE A PROFIT
by simple subtraction

This manufacturer knows his three R's—raceways, Rockrite and 'rithmetic. From actual records, he found ball bearing raceways machined from Rockrite Tubing instead of ordinary tube stock **cost 1.9¢ less per part.** • There are good reasons behind this profitable 'rithmetic. Sized by a distinctively different process, Rockrite Tubing has closer tolerances ... needs less machining, permits higher cutting speeds and feeds. In this case, machine output is approximately 60% higher. Work surfaces are better, too. • Want to do some cost subtraction yourself on tubular parts? Learn more about close-tolerance Rockrite Tubing. Send for Bulletin R2 today.

ROCKRITE® TUBING

ROCKRITE saves more than any other tubing

- **Higher cutting speeds**
- **Tools last longer between grinds**
- **Work-surface finishes are better**
- **Machined parts have closer tolerances**
- **Stations on automatics are often released for additional operations**
- **Extra-long pieces available—less downtime for magazine stocking and fewer scrap ends**
- **Closer tolerances often eliminate necessity for machining on outside or inside**

TR-123A

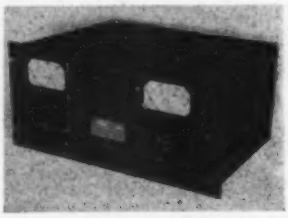
TUBE REDUCING CORPORATION • WALLINGTON, NEW JERSEY

NEW PARTS AND MATERIALS

D-C POWER SUPPLY 25

. . . has closely regulated outputs

Electronic Measurements Co., Red Bank, N. J.



Two continuously variable high-voltage outputs plus an unregulated low-voltage output are available.

Designation: 208-A.

Size: 19 in. wide, 8¾ in. high, 12 in. deep; weight, approximately 47 lb.

Service: Supplies 0-600 v d-c at 200 milliamp, 0-150 v d-c at 5 milliamp (both continuously variable) or 6.3 v a-c at 10 amp (unregulated); regulation within 0.5% from no load to full load on 0-600 v, within 1% at 150 v on 0-150 v; hum less than 5 mv; impedence less than 2 ohms at 20 cycles or more; line input, 105-125 v.

Design: Milliammeter and voltmeter included; positive or negative ground; voltages available from front or rear.

For more data circle MD 25, Page 189

HYDRAULIC PUMP UNITS 26

. . . for high-pressure power systems

Kobe Inc. Div., Dresser Equipment Co., 3040 *E. Slauson Ave., Huntington Park, Calif.*

These packaged pumping units, with integral electric drives, contain all accessories necessary for hydraulic power generation.

Size: Size 2 (15 hp)—43¼ in. long, 12 in. wide, 33 15/16 in. high; size 3 (30 hp)—52 in. long, 16¼ in. wide, 46 7/16 in. high; size 3 (50 hp)—same, except 55½ in. long.

Service: Operation from 220/440 v, 3-phase current; continuous service; replaceable plungers and liners provide the following ranges of service:

Size		Plunger (diam, in.)	Pressure (psi)	Displacement* (gpm)
2 (15 hp)	standard	1¼-¾	1550-4320	16.54-5.96
	special	11/16-7/16	5140-20,000	5.00-1.03
3 (30 hp)	standard	1¾-1	2010-5000†	25.61-8.36
	special	2¼-1⅞	1200-1750	42.34-29.40
3 (50 hp)	standard	1¾-1⅛	2260-5000†	37.86-15.65
	special	2¼-1⅞	1370-1970	62.58-43.36

* Nominal only. † To 10,000 psi available.

Design: Integral induction motor transmits power to crankshaft through double-reduction gears; each of 3 cylinders delivers fluid into common high-pressure manifold; ball type valves with stainless steel followers and springs; automotive type lubrication (splash and presrure) with scavenger pump for leakage, and crankshaft-driven lube pump; relief valve and pressure gage included.

For more data circle MD 26, Page 189

NEOPRENE CONVEYOR BELT 27

. . . for food and confectionery handling

Baldwin Belting Inc., 74 *Murray St., New York* 7, *N. Y.*

Tasteless, odorless and nontoxic, this belt is oil and waterproof, and can be washed.

Designation: Supertex Heavy or Standard.

Size: Belt width to 48 in.; cover thickness—Heavy, 1/32-in., Standard, 0.010-in.

Service: Washable with water, steam or concentrated cleaners; resists oil and greases; minimum shrinkage under water; tasteless, odorless and nontoxic; temperatures up to 250 F; little stretch; smooth surface leaves no impression on food products; resists acids and alkalies.

	3-ply	5-ply
Tensile Strength (per in.)	420 lb	700 lb
Recommended Load (per in.)	48 lb	80 lb
Minimum Pulley Diam	1 in.	1½ in.

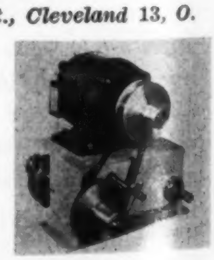
Design: 3 or 5 plies of light-weight (9.0 oz), closely woven duck are bonded with a 0.010-in. thickness of neoprene; edges are also bonded; surfaces are calendered and press-cured for smoothness; can be joined with alligator or clipper lacing, or made endless with vulcanized multiple step lap.

For more data circle MD 27, Page 189

VARIABLE-SPEED DRIVE 28

. . . powers rotating-test setups

Speed Selector Inc., 118 *Noble Ct., Cleveland* 13, *O.*



Accurate regulation and inherent stability permit close speed control during calibration or other tests.

Size: ½-hp—18¾ in. long, 13¾ in. wide, 15 in. high; 5 hp—34 in. long, 14 in. wide, 28 in. high; 10 hp—33½ in. long, 22 in. wide, 26 in. high; 2 hp, special.

Service: Driving rotating-test setups; 50:1 ratio with ½-hp, 5-hp drives, 16:1 with 10 hp; 150 to 7500 rpm for ½-hp unit (shown) with 1140 rpm motor; no hunting; absence of drifting holds speed variations to less than 0.25% over full range; control has zero backlash.

Design: Standard NEMA motor (open or explosion-proof with electrical characteristics desired) drives output shaft through 4 variable-pitch sheaves; chain-and-sprocket, hand knob or special control forces faces of "controllable" sheave together, causing stretchless, steel-cable V-belt to change PD of other 3 spring-loaded sheaves; prelubricated sealed ball bearings; sintered bronze bushings; regular or staticproof V-belts.

Application: Instrument, pump, or jet engine controller testing equipment.

For more data circle MD 28, Page 189

NEW PARTS

SILICA INSULATION 29

. . . for high temperatures

H. I. Thompson Co., 1733 Cordova St., Los Angeles 7, Calif.

Originally developed for jet aircraft, this fibrous material has less than half the weight and bulk of comparable insulating materials.

Designation: Refrasil.

Form: Fibrous silica, in bulk, batts, cloth, cordage, sleeving, tape.

Size: Fiber diam, 0.0002 to 0.0004-in.; batt thickness (nominal), $\frac{3}{16}$-in.

Service: Thermal insulation up to 1800 F; electrical insulation; filtration, with chemical resistance of pure silica; high flexibility, not affected by continued high temperature.

Properties: Low thermal conductivity; effective acoustical insulation; surface density, 0.05-lb per sq ft; specific heat, 0.19.

For more data circle MD 29, Page 189

STEEL WIRE 30

...with plated copper coating

Kenmore Metals Corp., 380 *Ninth St., Jersey City* 2, *N. J.*

Produced by a continuous electroplating process, this wire contains about 55 per cent less copper than solid copper wires.

Designation: Copperon.

Size: $\frac{3}{32}$-in. diam to No. 30 AWG (0.010-in.)

Service: For springs, float racks and lift rods, electric transmission lines, coils, leads; coating resists damage from temperature changes, hot rolling or cold drawing.

Properties: Low, medium or high-carbon steel core; electrical conductivity at high frequencies comparable to solid copper wires; corrosion resistant; high dimensional stability and mechanical strength; weight, approximately 9% less than same-size solid copper wires.

For more data circle MD 30, Page 189

ENGINEERING DEPARTMENT

EQUIPMENT

For additional information on this new equipment, see Page 189

DRAFTING TABLE 31

. . . of all-steel construction

Emrick Inc., 1724 *Clinton Ave., Kalamazoo, Mich.*

Rigidity is assured by all-steel construction, reinforced by steel angle supports.

Size: Drafting board, 72 x 42 x 1 in.; height, adjustable from 33 to 47 in.; leg base area, 42 x 25½ in.; pencil tray size, 39 x ½ x 12 in.; shipping weight, 146 lb.

Service: Top adjustable from 0 to 50 deg; shipped knocked-down.

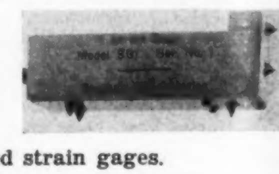
Design: Sugar-pine top with tongue-and-groove joints; equipped with leveling device; all-steel base with adjustable footrest.

For more data circle MD 31, Page 189

ELECTRICAL STRAIN GAGE 33

. . . can be calibrated accurately

Statham Laboratories Inc., 12401 *W. Olympic Blvd., Los Angeles, Calif.*



Mass of the moving parts of this gage is small, permitting faithful dynamic recording with the same strain indicators used with bonded strain gages.

Designation: SG-1.

Size: Two knife-edge sets, 1.5 in. spacing for displacements to ±0.003-in., and 0.375-in. spacing for ±0.012-in.; overall size, 2¼ in. long, ¾-in. wide, ¾-in. high.

Service: Gage factor, approximately 2; accuracy and linearity, within 1% of full scale; resolution, within 0.1% full scale; can be mounted with rubber bands, tape or spring clamps; gages individually calibrated.

Design: Unbonded resistance-wire transducer element; two active resistance arms; supplied with 5-ft cable, mahogany case.

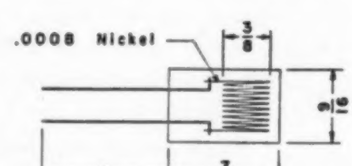
For more data circle MD 33, Page 189

RESISTANCE THERMOMETERS 32

. . . cemented to high-temperature surfaces

Ruge-de Forest Inc., 84 *Massachusetts Ave., Cambridge* 39, *Mass.*

Small in size, these bonded Bakelite resistance thermometer elements have high stability and long life.



Designation: BN-3, BN-4 Stikons.

Size: BN-3, ¾-in. long, 5/16-in. wide; BN-4, ⅞-in. long, 7/16-in. wide; both are 0.006-in. thick, have 1 in. leads.

Service: Temperature indication in range −100 to +300 F; can be used to 350 F for reduced service, to 400 F on short runs; resistance (70 F)—BN-3, 50±2 ohm, BN-4, 200±2 ohm; resistance tolerance tested individually and marked; charts for conversion of resistance values to deg F or C are furnished.

Design: Nickel wire (0.0008-in. diam) bonded between Bakelite wafers; No. 30 tinned wire leads.

Application: Measuring temperature on rotating shafts or propellers with slip rings; telemetering of flight and rocket temperature data.

For more data circle MD 32, Page 189

ELECTRONIC RELAYS 34

. . . provide sensitive control in laboratory

Emil Greiner Co., 20-26 *N. Moore St., New York* 13, *N. Y.*

Models provide extreme sensitivity or mechanical ruggedness.

Designation: E-1, E-2, E-3.

Size:

Model	Height (in.)	Width (in.)	Depth (in.)	Control Lead (length, ft)
E-1	6⅛	5⅛	4	25
E-2	7⅛	7	3⅞	40
E-3	8	7¼	5¾	unlimited

Service: Sensitive laboratory relay control with characteristics as follows:

Model	Load (amp)	Load (v)	Control (microamp)	Control (v)
E-1	10	115 a-c, d-c	15	35 a-c
E-2	30	115 a-c	6	6.3 a-c
E-3	30	115 a-c	3	16 d-c

Design: Normally off or on operation, changed with metal jumpers on E-2 and 3, by separate terminals on E-1; mercury-to-mercury contacts on E-2, E-3, precision switch on E-1; E-3 has isolating transformer, permitting grounding on either side of line.

For more data circle MD 34, Page 189

HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

80. Selecting Electrical Instruments
Westinghouse Electric Corp.—30-page illustrated booklet B-4696 presents information on how to select electrical measuring instruments. Seven basic selection factors are explained and instrument types available in major classifications are listed on check chart. Portable, switchboard, panel, recording and socket instruments are described and functions explained.

81. Laboratory Microscopes
Bausch & Lomb Optical Co.—Ball bearings and rollers throughout focusing system are one of main design features of Dynoptic Labroscope line of laboratory microscopes on which full descriptive information can be found in 24-page illustrated catalog D-185. Price list is supplemented.

82. Shell-Molding Process
Borden Co., Chemical Div.—"What You Should Know About the Shell-Molding Process" is title of 8-page illustrated booklet which traces development of what formerly was known as C-process. Uses and advantages are explained, and data on what equipment and materials to use, plus technical information, are included.

83. Welding Accessories
Empire Products, Inc., Cam-Lok Div.—Cable connectors, electrode holders and terminal connections are subject of 4-page illustrated bulletin "Welding Accessories."

84. Tube Fittings
Crawford Fitting Co. — Leakproof Swagelok tube fittings in full range of sizes in brass, aluminum, steel, stainless steel and Monel constructions are dealt with in 12-page illustrated catalog B-151. Dimensions, cross-sectional drawings, installation recommendations and assembly instructions are included.

85. Wire Cloth Strainers
Michigan Wire Cloth Co.—Guidance in selection of wire cloth weave, mesh, wire size and metal selection as well as the correct strainer size, shape and construction is provided in "Engineer's Manual of Wire Cloth Strainer Design." Booklet also outlines technical assistance, sample kits and catalogs which are available for those concerned with strainer engineering and design.

86. Air, Hydraulic Water Cylinders
Ortman-Miller Machine Co.—28-page illustrated catalog contains engineering specifications, data on internal locking system and listing of parts on air, hydraulic and water cylinders. Standard, oversize and 2-1 piston rod data are included.

87. Small Snap-Action Switch
Sessions Clock Co.—Illustrated data sheet 101-R contains specifications and application information on type A basic Tyniswitch. This miniaturized snap-action control carries UL rating of 15 amp at 125 v ac. It requires operating force of 7/10-oz and has movement differential of 0.002 to 0.006-in.

88. Expanded Metal Meshes
Penn Metal Co.—28-page illustrated catalog "Expanded Metal Meshes" explains uses of expanded metal in conserving steel and other critical metals while also saving weight, allowing free passage of air and light, performing decorative functions and permitting flexibility in construction not poss'ble with solid metal. Catalog bears No. 493EM.

89. Valve Positioner
Conoflow Corp.—Details of the new Cono Rotomotor for positioning control of catalyst slide valves, large gate valves, heavy dampers, blast gate valves and similar heavy duty service are presented in 8-page illustrated bulletin. These actuators are pneumatic gear driven devices.

90. Anticorrosion Treatment
Octagon Process, Inc.—Anchorite 100, a paint-anchoring corrosion - resistant phosphate treatment for metals is subject of 8-page illustrated booklet. Described in detail are common causes of paint failure and how they can be prevented. Immersion and spraying methods, as well as typical products to which process can be applied, are discussed.

91. Explosionproof Motors
U. S. Electrical Motors, Inc.—Features of various types of explosionproof and nonexplosionproof electric motors are described and illustrated in 8-page form 1629. Lubriflush bearings, split hub fan, high draft ventilation, removable cover and asbestos protected windings are incorporated.

92. Nonferrous & Stainless Fasteners
H. M. Harper Co.—56-page price list and stock book describes complete line of nonferrous and stainless steel fasteners. All are listed by alloy and type. Everlasting fastenings carried in stock include brass, bronze, copper, Monel, aluminum as well as stainless steel.

93. Stainless Steels
Babcock & Wilcox Tube Co.—Technical data card 148 presents condensed and tabulated information on hot working, annealing, welding, machining and forming of B & W Croloy austenitic stainless and nonhardenable and hardenable ferritic stainless steels.

94. High Frequency Generators
Bogue Electric Mfg. Co.—Design and operating data including complete ratings and dimension tables are presented in 8-page illustrated brochure 440 on 400-cycle high frequency generators. Units can be engineered to operate at any speed from 1200 to 24,000 rpm.

95. Iron Innoculant
International Nickel Co.—"Nisiloy for Gray Iron Castings" is title of 8-page illustrated folder describing this innoculant which is metallurgically designed to improve machinability, add toughness and increase resistance to wear. Product reduces localized hard areas or chilled edges in gray iron castings and provides dense but machinable structure throughout.

96. Sump Type Liquid Filters
Marvel Engineering Co.—Engineering data on synclinal type filters for sump or line installation on all hydraulic and low pressure liquid recirculating systems are included in 8-page illustrated folder 105. Single unit capacities range from 5 to 100 gpm and filter meshes from 30 to 200.

97. Packing Units
Chiksan Co.—Line of packing units for various applications is listed in 4-page illustrated data sheet "Chiksan Packing Units." All units are self-adjusting under vacuum or pressure. When in service, packing unit cannot be forced out under any conditions.

98. Stampings
Laminated Shim Co.—"Service in Stampings" is title of 12-page booklet for users of stampings. Discussed is preparation of stampings specifications which will insure lowest possible quotation. Facilities of company for complete stamping service are outlined.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below

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99. High-Speed Motion Picture Camera
Wollensak Optical Co.—12-page illustrated bulletin "Fastax High-Speed Motion Picture Cameras" covers uses of this precision equipment for industrial development and research. Cameras are capable of taking pictures at rate of 150 to 14,000 frames per second. When projected at normal speed of 16 frames per second, time magnifications of 10 to 875 are obtained.

100. Rotary Switches
Arrow-Hart & Hegeman Electric Co.—12-page illustrated bulletin AS-851 catalogs line of rotary Packet switches which are designed for controlling electric circuits operating at current ratings of 10 to 500 amperes and ratings from 115 to 600 v ac and up to 250 v dc. These controls permit custom-built switches to be constructed from standard components.

101. Flexible Remote Controls
American Chain & Cable Co., Automotive & Aircraft Div.—12-page guide book "The Key to Remote Control" shows pictorially how Tru-Lay Push-Pull flexible controls can be used for transferring movements from one location or mechanism to another. Available sizes, standard assemblies, bracket type heads, sliding sleeves, terminals and other data are discussed and applications explained.

102. Precision Springs
Newcomb Spring Corp.—"66 Hints to Simplify Design and Reduce Spring Costs" is title of 8-page bulletin NS 500 compiled for spring designers and purchasers. Hints are grouped under following headings: purchasing; materials; finishes: gages; general hints on all types of springs; hydrogen embrittlement; compression, extension and torsion springs; and table of spring materials.

103. Floating Disk Clutches
Carlyle Johnson Machine Co.—Offered to machine and product design engineers is 1951 edition of Maxitorq installation and data book No. 51 which pictures and describes with specifications standard floating disk clutches in eight sizes from ¼ to 15 hp at 100 rpm. Included are special driving cups for pulley type, cut-off coupling and ring type installations.

104. Electric Contact Controllers
Minneapolis-Honeywell Regulator Co. — 16-page illustrated catalog 8000 describes vane type electric contact controllers for use with Electr-O-Vane thermometers and pressure gages, ElectroniK potentiometers and Pyr-O-Vane and Protect-O-Vane millivoltmeters. They give snap-action on-off, two-position or three-position control.

105. Ultrasonic Testing Service
Sperry Products, Inc.—Commercial ultrasonic testing services of metals and other materials in the field and in the laboratory are described in 8-page illustrated bulletin 50-115. This nondestructive testing technique uses Reflectoscope and Reflectogage to locate flaws and to measure thicknesses from one side of material.

106. Polyethylene Flame Spraying
Linde Air Products Co.—Complete and detailed instructions for flame spraying of Polyethylene plastic resin on metal surfaces are offered in 8-page illustrated form F-7789. Booklet also presents tabulated record of inorganic, organic and petroleum products to which coated metals have been exposed. Safety precautions are considered as well.

107. Asbestos Fabric Packings
Raybestos-Manhattan, Inc., Packing Div.—Complete line of "R/M Asbestos Fabric Packings" is illustrated and described in 4-page bulletin of same title. Included are service recommendations, available sizes, standard packages and packaging specifications for high pressure rubber back, rubber core and dual edge packings.

108. Pressed Metal Facilities
Pressed Metal Institute—Copies of revised supplement to "Blue Book of Stamping Manufacturers" gives facilities of Pressed Metal Institute members. Book lists only reliable and competent sources of supply.

109. Casters, Trucks & Conveyors
Rapids-Standard Co.—Aid to selection of correct type of industrial caster is provided by photographs, sketches and charts in 28-page booklet "Material Flow is the Bloodstream of Business." Also included are details of conveyors and trucks made by company.

110. Induction Heating
General Electric Co.—Forging, hardening, brazing and annealing applications at 1000, 3000 and 10,000 cycles for induction heating equipment are described in illustrated booklet GEA-5679. It explains components and requirements of induction heating with motor-generator type equipment and covers forge welding, heating drill bits, continuous heating of moving strip and surface hardening.

111. Drawing Reproduction Paper
Eastman Kodak Co., Industrial Photographic Div.—How short cuts and savings have been effected in several industrial firms through the use of Kodagraph Autopositive paper are cited in 12-page illustrated bulletin F1-53. This collection of case histories presents problems faced by ten companies and shows their solutions.

112. Hydraulic Cylinders
Rivett Lathe & Grinder, Inc.—Designers are offered a complete file on hydraulic cylinders in 12-page catalog No. 105 which illustrates and describes 108 different models, each in ten bore diameters. Drawings and specifications are furnished for all standard and cushioned types, standard rod and 2:1 over-size rod, single and double end rods, internal and external threads.

113. Coatings, Adhesives, Sealers
Minnesota Mining & Mfg. Co.—Research assistance in using adhesives, coatings and sealers in product design and engineering is available in 8-page illustrated handbook. It reports availability of 1000 different basic formulas and has technical data on 11 adhesives, 7 coatings and 7 sealers. Sixteen design problems and their solutions are covered.

114. Aluminum Bronze Alloys
Ampco Metal, Inc.—Corrosion-erosion resistance and cavitation-pitting data, along with physical and chemical properties of various aluminum bronze alloys recommended for such service are included in 20-page illustrated bulletin PI-3. Information on corrosion resistant aluminum-bronze centrifugal pumps, plug valves, pipe, tube fittings, tube sheet and testing facilities is included.

115. Belt Conveyor Carrier
Stephens-Adamson Mfg. Co.—16-page illustrated bulletin 2-C contains specifications and general information op line of belt conveyor carriers, made in styles and widths for every belt conveyor. Included are various ball and roller bearing, picking table, auto-tilt, super duty, impact and low headroom carriers and upper and lower guide rollers.

116. Hard, Soft & Sponge Rubber Parts
Roth Rubber Co.—Facilities for producing molded, extruded and die-cut parts of hard, soft and sponge rubber are described in 12-page illustrated booklet "Roth Research Brings Results with Rubber." Products include range of natural and synthetic compounds including sponge, silicone, abrasion-resistant and other rubbers.

117. Plastic Molding Facilities
Molded Products Corp.—16-page illustrated "Data Book of MPc Facilities" is intended to aid designer and buyer in evaluating company's capacity for plastic molding. Buildings, equipment, resources and experience are described. Products produced range from buttons to radio cabinets and dials to gears.

118. Air Conditioning Pumps
Allis-Chalmers Mfg. Co.—Engineered for air conditioning equipment and other fractional horsepower applications, line of package pumps offered in capacities to 80 gpm at heads to 100 ft are described in illustrated data sheet 52B7529. Open and closed impeller close-coupled, pedestal mounted and open impeller vertical mounting types are offered.

119. Motors & Transformers
Wagner Electric Corp.—Characteristics, ratings and applications for various types of motors, including polyphase squirrel-cage, single phase, direct current and gear motors, are given in 4-page illustrated data sheet. Electrical and enclosure types also are covered, as are single and three-phase dry type transformers.

120. Copper Corrosion Resistance
American Brass Co.—24-page booklet "Corrosion Resistance of Copper and Copper Alloys" presents findings of 25 years of laboratory and field research. Chemical and physical nature of corrosive attack is explained. Included is table showing resistance of principal types of copper and copper base alloys when in contact with 183 different corroding agents.

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THE ENGINEER'S

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Theory of Perfectly Plastic Solids

By William Prager, professor of applied mechanics, Brown University, and Philip G. Hodge Jr., assistant professor of mathematics, University of California; published by John Wiley & Sons Inc., New York; 264 pages, 6 by 9 inches, clothbound; available from MACHINE DESIGN, *$5.50 postpaid.*

Not intended as an extensive treatise on the general theory of plasticity, this book deals with one particular branch—perfectly plastic solids—and is written as an introduction to the subject. According to the authors, this branch of the theory has most nearly taken definitive form, yielding results of practical importance to the designer.

Two theories of perfectly plastic materials are considered: the theory of Saint Venant-Levy-Mises, which neglects elastic strains, and the theory of Prandtl-Reuss, which takes account of elastic as well as plastic strains. Some of the material on limit analysis as applied to these two theories is published for the first time.

Introductory chapters discuss basic concepts, trusses and beams, and torsion of cylindrical or prismatic bars. Plane strain is considered next. Specific subjects covered in four chapters are: problems with axial symmetry, general theory, specific problems, and contained plastic deformation and limit analysis. Extremum principles, applications of limit analysis to the theory of perfectly plastic solids, are contained in the last chapter.

□ □ □

Mathematical Engineering Analysis

By Rufus Oldenburger, Woodward Governor Co.; published by Macmillan Co., New York; 426 pages, 6 by 9¼ inches, clothbound; available through MACHINE DESIGN, *$6 00 postpaid.*

In industrial research, the problem of stating a physical engineering situation in the form of an equivalent mathematical expression is often extremely difficult. This book was written with the objective of making the transition easier for the engineer. In addition to methods for developing basic laws of engineering from a minimum number of assumptions, techniques for making these simplified assumptions are covered. Mathematical techniques for solving problems already expressed in mathematical form, however, are not

considered. The book assumes a working knowledge of calculus.

Mechanics of rigid bodies, electricity and magnetism, heat, elasticity, and fluid mechanics are the subjects of the five main sections. Practical applications for specific types of equipment are given, as well as a complete set of problems for each section.

□ □ □

Machine Drawing

By Deane Lent, associate professor of engineering drawing, Massachusetts Institute of Technology; published by Prentice Hall Inc., New York; 560 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$7.75 postpaid.*

Rather than merely covering the mechanics of drafting, this book attempts to provide an insight into manufacturing procedures and processes. The text is in three sections: the first short section is devoted to the design phase; the next, much wider in scope, covers detail drawing, dimensioning, manufacturing processes, manufacturing accuracy and the technique of precision drawing; and the final gives procedures and methods for making assembly drawings.

New Standard

*Screw Thread Gages and Gaging—ASA B*1.2-1951: Following the publication of B1.1-1949, Unified and American Screw Threads, this new American Standard for gages and gaging is designed to facilitate adherence to thread dimensions of the B1.1 standard under production conditions. Fundamentals of gaging, and design and marking of gages, are covered, with gage tolerances, wear allowances and size limits for gages following. Tolerance limits for GO, HI, LO (former "Not Go"), and plain gages are divided into three classes: W (highest commercial accuracy), X (generally accepted tolerances—greater than W tolerances), and Z (standard tolerances for plug gages). Constants for computing gage dimensions, formulas for gage limits, lengths of standard thread plug-gage blanks and standard thread ring and setting plug-gage blanks are given. Wire methods of measurement are also described. Copies of this 86-page Standard are available at $4.00 each from the American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y.

Association Publications

Standards for Laminated Thermosetting Products —LP1-1951: Performance characteristics of laminated plastics have been co-ordinated with military requirements in this NEMA standard. Information concerning the manufacture, testing and performance of laminated thermosetting sheets, rods and tubes is given. These laminated products are defined as consisting essentially of fibrous sheet materials, impregnated or coated with a thermosetting resin binder and consolidated under high temperature and

pressure. The publication describes grades and contains standards for form, color, finish, thickness, diameter, length, width, flexural strength, impact and bonding strength, water absorption, dielectric strength, dissipation factor, arc resistance, density and compressive strength. The 47-page standard costs $1.00 per copy and may be obtained from the National Electrical Manufacturers Association, 155 E. 44th St., New York 17, N. Y.

Advantages of the Gray Iron Casting Process and Products: Scheduled to be the fifth chapter in the forthcoming *Gray Iron Handbook* this 28-page booklet is chiefly concerned with the relative status of the gray-iron casting process as compared with other manufacturing processes. Section headings are: functional advantages of castings; economic advantages of the casting process as a manufacturing method; gray iron vs. other cast metals; general conclusions. Written by C. O. Burgess, the 6 by 9 inch booklet is available from the Gray Iron Founders' Society Inc., 210 National City—E. 6th Bldg., Cleveland 14, O., for $1.00 to members, $1.50 to nonmembers.

The Strange Case of the Seven-Sided Post Hole: This whimsical little booklet tells the story of the adoption of standards by the Association of Post Hole and Hole Post Equipment Manufacturers and Fabricators Inc. Presented in a clever, quick-reading cartoon style, the booklet presents the basic reasons for adoption of standards. Copies of the 5 by 9-inch, 44-page booklet may be obtained without charge from the American Standards Association, 70 East 45th St., New York 17, N. Y.

Manufacturers' Publications

Defense Production Data from the Houghton Line: Heat-treating setups and metalworking production methods for military components are described and illustrated in this 52-page booklet. Many manufacturing steps in the production of shells, cannon, small arms, ammunition, rockets and tank parts are reviewed, along with miscellaneous related subjects such as cold extrusion of steel, machining, metal cleaning, and rust preventives. Information included in the 25 short articles comprising the booklet is drawn both from 1941-45 war experience and 1951-52 data. Size of the booklet is 8½ by 11 inches, and copies are available to metal-working plants filling defense orders from E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

Metco Metallizing Handbook: Written to give an understanding of the technical and practical aspects of metallizing (spraying molten metal onto a surface to form a coating), this fifth edition includes most of the recent data on metallizing. The metallizing process is discussed generally, then machine element work is considered. Corrosion-resistant coatings and miscellaneous applications are presented, followed by

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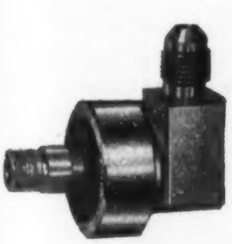

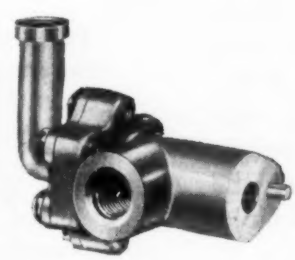

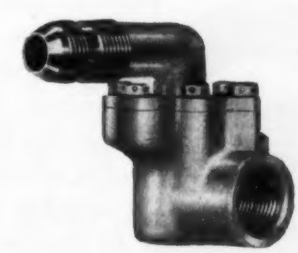

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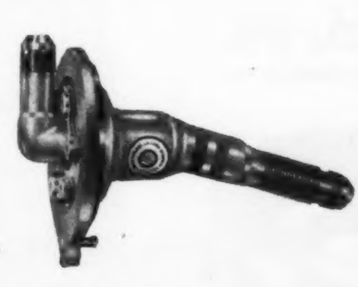
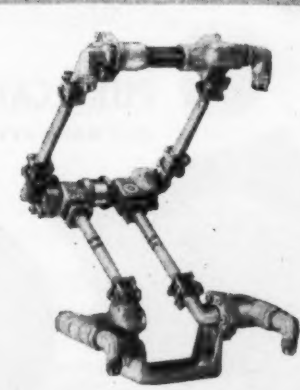




FREE ENTERPRISE—THE CORNERSTONE OF AMERICAN PROSPERITY

a review of the Metco Sprayweld process for hard facing. Several chapters give engineering properties of sprayed metal, and describe correct ventilation and safety procedures for metal spraying. H. S. Ingham and A. P. Shepard are the authors of this 249-page, 6 by 8½ inch, cloth-bound handbook. Price is $3.00 from the Metallizing Engineering Co. Inc., 38-12 30th St., Long Island City 1, N. Y.

United States Government Specification Finishes: Published by a finish manufacturer, this 7 by 10 inch booklet gives government specifications for 21 of the more common military finishes. A short description of the finish, color specifications, thinning and application procedure, and drying time are given for each. Copies can be obtained by request on company letterhead from the Egyptian Lacquer Mfg. Co., Box 444, Newark 1, N. J.

Photoelastic Stress Analysis: Methods followed and equipment needed for photoelastic stress analysis (using plastic models and polarized light to determine stress patterns) are covered. A discussion of the principles of photoelasticity is first in this 16-page booklet, followed by a review of apparatus necessary for photoelastic stress analysis studies. Model materials and a description of necessary photographic materials are covered briefly. Included is a bibliography of books and articles, and a list of manufacturers of equipment. Illustrated with full-color and black-and-white photographs, this 5¾ by 8½ inch booklet is published by Eastman Kodak Co., Rochester 4, N. Y., and is available for 35 cents from Kodak dealers.

Facts About Plastics: Designed to give a basic understanding of the many different types of plastics now in use, this 24-page booklet contains a brief listing of various plastics, reviews the various ways in which they are produced, and illustrates uses of plastics in industrial and consumer products. Subjects include: plastics advantages and limitations, thermosetting and thermoplastic materials, how laminated and molded plastics are made, design suggestions for molded-plastic parts, and comparative properties of Insurok laminated plastics. Facilities and services of the company are described. Available by request on company letterhead, this booklet may be obtained from Richardson Co., 2764 Lake St., Melrose Park, Ill.

Professional Viewpoints

"... changes and omissions lay me open to criticism"

To The Editor:

My article, "Are the Russians Ahead in Mechanism Analysis?" (MACHINE DESIGN, September 1951) contains editorial changes and omissions that lay me open to criticism either of being ignorant of the true

facts or of willfully suppressing available information. In fairness to me, it seems that you should publish the omitted parts and remedy those passages which do not present the facts correctly, as I stated them.

In the first place, my original title, "The Science of Mechanisms in Russia," was more comprehensive inasmuch as I did not restrict my discussion to analysis only.

I object to your use of the words "author's correspondent" in place of my wording "that professor" (Artobolevskii) in the second paragraph, as your version implies a continued relationship, which does not exist.

In line 23, Page 127, the words "and has done so already" should have been retained after "multitude of papers."

In the last line on Page 127, this sentence of mine was omitted: "Institutional or public help has not yet been offerred in spite of the attempts by the author, thus leaving the content of Russian works difficult to digest."

In line 11 of Page 200, after "theory of mechanisms," these three sentences were omitted: "He (Chebychev) produced many mechanisms and methods for dealing with them. A book on his achievements is available here. Most of the mechanisms shown in it are only of academic interest and some are quite impractical."

The next sentence should have begun, "After Reuleaux, in Germany, had introduced in 1864 the concepts of . . . ."

Line 14, Page 200, should have included the words, "as the first," following "1869." This was inserted purposely by me to thwart complaints that I am not giving credit where credit is due.

The last paragraph on Page 200 should have begun: "His method consists in developing from a crank or an already existing mechanism new ones by the addition of 'groups of links,' the type, number, and arrangement of which determine their class and order. Starting with ternary links, they can be arranged in line, with binary links branching off from the free elements as 'leads' or 'ties,' *Fig.* 1, by which the group is attached to the cranks, links, or frame of an existing mechanism, or new ternary links may branch off from the 'internal' ternary links, *Fig.* 2, or they may form closed figures or 'contours' that are attached either directly, or by 'leads' to cranks, links, or frame of an existing mechanism, *Fig.* 3."

The sentence starting on line 24 on Page 202, should have read: "His method received publicity through the wide distribution, in his lectures, of lecture notes, although . . . ."

At the middle of the same page, a paragraph was omitted following the words "in the thirties." This paragraph read:

"There are a number of objections to the Lynen-Assur method, first, that it is rather superficial, second, and most important, that it deals with *mechanisms* and not with the more general concept of the *kinematic chain*, which was considered in detail by M. Gruebler."

In line 10, Page 204, after ". . . has not been solved"


you Specify *
if it's a wire spring .
spring washer . . . . .
flat spring . . . . . .
or wire form . . . . .
we make it!
Wallace Barnes Springs
Bristol Connecticut

the sentence should have read: "by the Russians. Nor has it been solved elsewhere, in spite of . . . ." This latter comment is my own and does not refer to the Russians.

At the middle of Page 204, two paragraphs were omitted following the words "automatic lathe." These paragraphs should read:

"In particular, it considers the fundamental divisions for a rational description of automatic machines, the description of the technological process, the general description and analysis of an automatic machine ('automaton'), the description and analysis of the drive and driving mechanisms, the relations between the periods of motion and rest of the mechanisms of the automaton, and the cycle of the technological process, the latter being analyzed by means of 'cycle diagrams.'

"Unfortunately, there is no translation available as yet of this important monograph."

The omission of these paragraphs lays me open to the charge of deliberately suppressing available information by not explaining the method by which this new treatment is achieved. It also robs the reader of the opportunity of appraising its value.

In the last paragraph of Page 204, the second and succeeding sentences should read: "While the Germans approximate a desired curve by passing a 'coupler curve' through up to five points of the desired curve, the Russians pass through the given curve one of a family of curves of known analytic equation, in the case of mechanisms one of a family of coupler curves, or other curves expressible in polynomials. They determine then, by means of Chebychev polynomials, the maximum deviation of this curve from the given curve and minimize this to obtain the least deviation from zero. The curve resulting from this procedure is a much closer approximation than that obtainable by any other method, including that of the method of least squares, and closer and much more certain than that resulting from the German method of passing a coupler curve, or other curve, through the five given points."

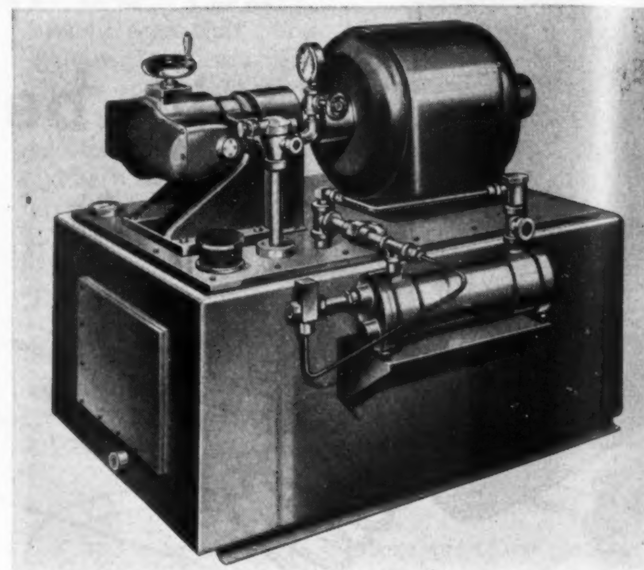
The sentence starting on line 10, page 206, while given correctly by you as per a change made in my manuscript, I would rather have read as follows: "This method is known in Russia as the Chebychev Theory of Synthesis."

While there are other changes from my original manuscript, the ones corrected here are the most important ones; and I shall appreciate it if you would publish the foregoing in an early issue of MACHINE DESIGN.

—A. E. RICHARD DE JONGE
New York, N. Y.

Our apologies to Mr. de Jonge and to our readers for having had to cut out portions of his article because of space limitations. Changes in sentence structure were intended to improve readability, not to change the meaning which they apparently did in some places. We welcome this opportunity to set the record straight by publishing Mr. de Jonge's letter.—ED.

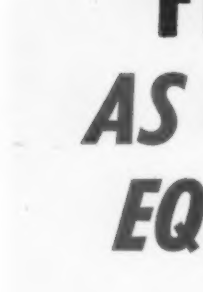
MORE MACHINE MANUFACTURERS INSTALL MARVEL SYNCLINAL FILTERS AS ORIGINAL EQUIPMENT



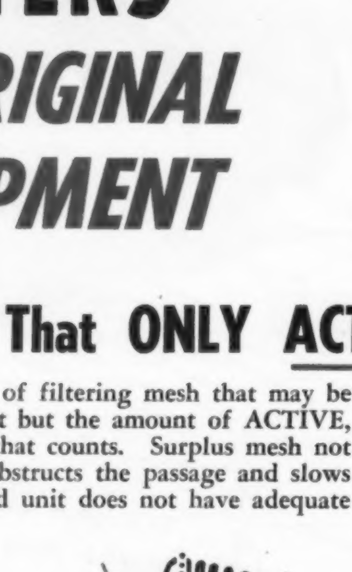
Large series hydraulic pumping unit manufactured by The Denison Engineering Co., Columbus, Ohio to recommendations of the Joint Industrial Conference. These pumping units are equipped with Marvel Synclinal Filters.

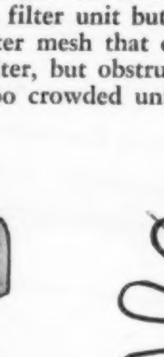
They Know That ONLY ACTIVE FILTER AREA COUNTS!

It isn't the total amount of filtering mesh that may be squeezed into a filter unit but the amount of ACTIVE, WORKING filter mesh that counts. Surplus mesh not only fails to filter, but obstructs the passage and slows the flow. A too crowded unit does not have adequate space for storage of accumulated foreign matter—tightly packed pleats of mesh can soon become clogged with filtered out material. Marvel Synclinal Filters are balanced to provide maximum mesh area for all the liquid which can pass through the space and allow necessary room for filtered out material. That is why they excel in maintaining efficiency through longer periods between cleanings. Not only is the frequency of cleaning reduced, but disassembly, cleaning and reassembly is so simple that ordinary workmen can do it quickly.



LINE TYPE (cutaway)





SUMP TYPE (cutaway)

Meets J.I.C. Standards

FACTS — NOT CLAIMS

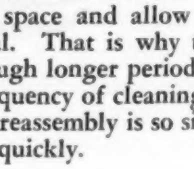
"Campaign promise" claims mean little to engineers. They want the record, measurable facts. That is why over

240 MANUFACTURERS

have picked MARVEL SYNCLINAL FILTERS AS THEIR O.E.M. CHOICE

Sump and line models available in capacities from 5 to 100 g.p.m. Mesh sizes from 30 to 200. All models operate in any position. Line models may be serviced without disturbing pipe connections. For efficient filtration of non-corrosive liquids in hydraulic and low pressure systems, Marvel has your answer.

For complete engineering data write for catalog 105.

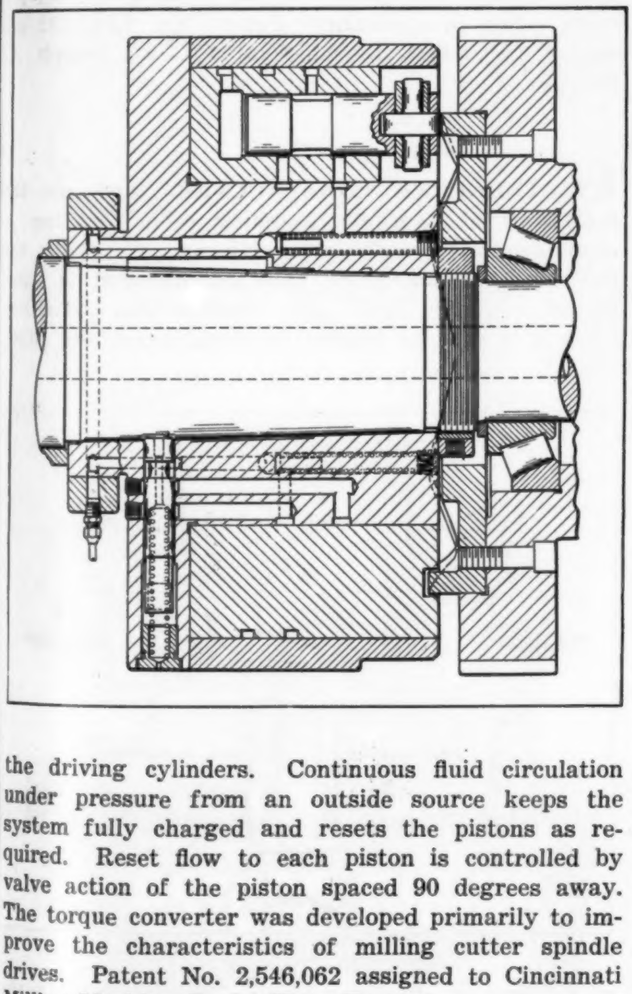


MARVEL ENGINEERING COMPANY
625 W. Jackson Blvd. Chicago 6, Ill.

NOTEWORTHY

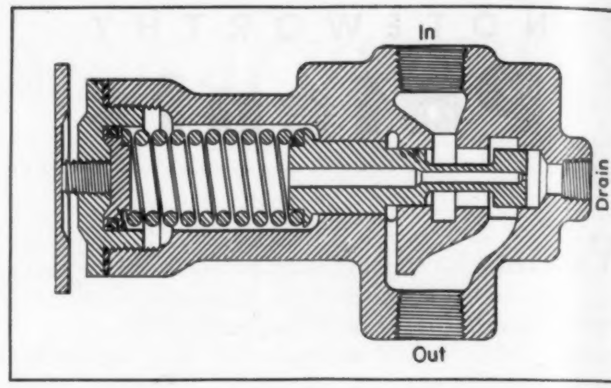
Patents

VARIABLE SLIP, inversely proportional to speed, of a cam-actuated piston type hydraulic torque converter smooths out power transmission in either direction to the driven member, the fluid action providing damping effect on vibration. Centrifugal force positions the spring-loaded control valves which automatically vary the slip rate, from practically zero at slow speed to approximately two per cent at high speed, by metering the escape of trapped fluid from



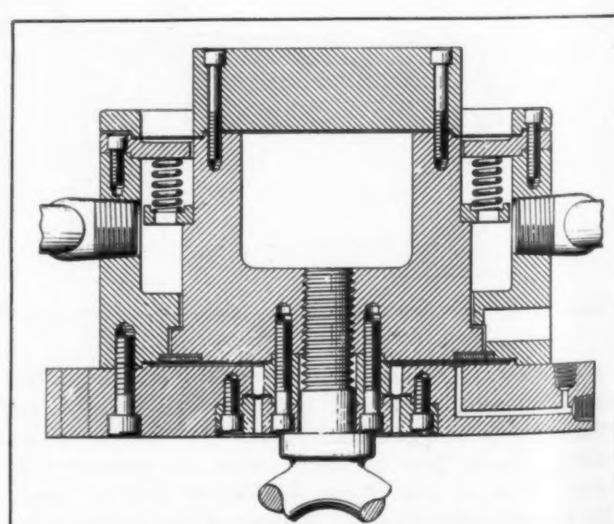
the driving cylinders. Continuous fluid circulation under pressure from an outside source keeps the system fully charged and resets the pistons as required. Reset flow to each piston is controlled by valve action of the piston spaced 90 degrees away. The torque converter was developed primarily to improve the characteristics of milling cutter spindle drives. Patent No. 2,546,062 assigned to Cincinnati Milling Machine Co. by Hans Ernst.

REDUCTION OF STATIC FRICTION in a hydraulic pressure-reducing valve is accomplished by provision of minimum valve overlap so that relatively slight movement is required to close or open the valve. This causes continuous valve motion even though service flow demand may be nil. Said to enable precise pressure control in reduced pressure branches of a system, the normally open valve is ac-



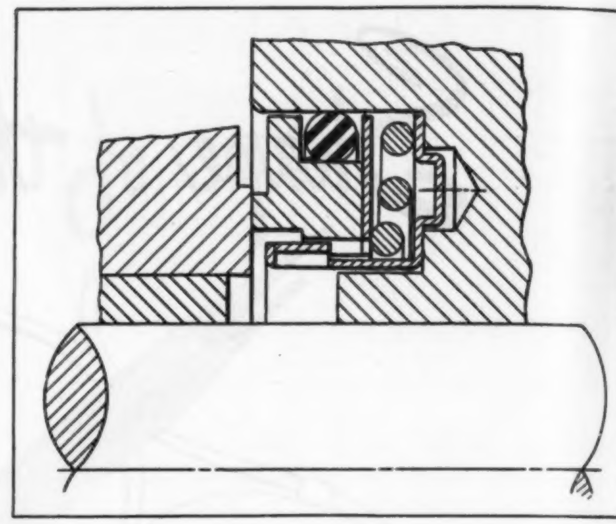
tuated solely by pressure on the delivery side, being unaffected by fluctuations occurring on the inlet side. Dashpot cushioning of the adjustable spring-loaded valve provides additional stabilizing effect. Normal spool leakage constitutes the only fluid loss from the valve when in operation. Patent No. 2,563,192 assigned to H-P-M Development Co. by Joseph A. Scruggs.

FRICTION-FREE CONSTRUCTION increases the sensitivity of hydraulic weighing cells, resulting in more accurate weight measurement. Necessity for the usual tension guide yoke arrangement is eliminated by triple diaphragm construction. Whether the cell is used in tension or compression, the effect



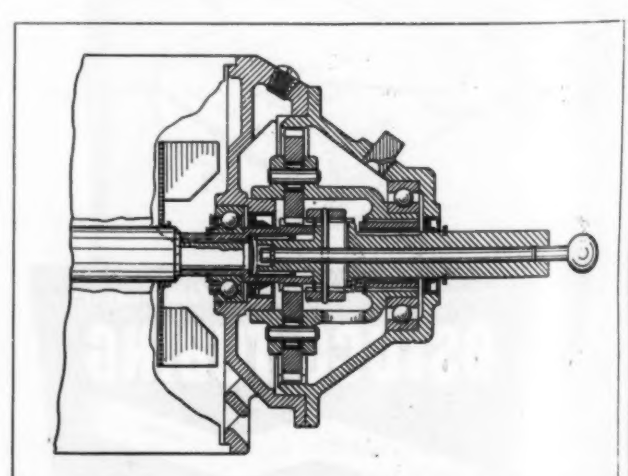
of angular or off-center loading is minimized by the guiding action of the diaphragms. Compression springs preload the piston assembly, insuring instant fluid reaction to applied loads. Patent No. 2,561,321, assigned to Baldwin-Lima-Hamilton Corp. by Malcolm C. Tate.

DROP-IN INSTALLATION rather than the usual pressed-in assembly is the principal objective of a new face-type shaft seal design. The familiar O-ring provides the static seal between the housing and the



loosely keyed seal ring, while a compression spring arrangement maintains constant thrust. Projections from the end surface of the retainer ring fitting into drilled blind holes prevent rotation of the assembly. Patent No. 2,554,406, assigned to Crane Packing Co. by Shirrel A. Hastings and James H. Thayer.

PLANETARY GEAR TRANSMISSION built into the end housing of electric motors permits either direct drive from the rotor to the output shaft, or reduced output shaft speed. Speed selection is accomplished by shifting the control rod which extends through the output shaft. Stop-rings seated in the control rod maintain the selected gear shift position, and also allow neutral positioning of the positive clutch ring. The transmission section is sealed from



the motor bearing assembly, and the housing is designed to utilize the motor fan for also cooling the transmission. Patent 2,545,040 as granted to Ralph H. Morgan has been assigned to Charles Drexler Company, Inc.

Complete printed copies of all patents are available from the Commissioner of Patents, Washington 25, D. C., for 25 cents each.

Vibration Failures

(Concluded from Page 160)

attention to one mode of vibration associated with those failures.

Many design changes have been tried with the object of reducing those modes which are excited by stator vanes. These include increasing the stator clearances and spacing the stators unequally. There has also been a reduction in the number of stator vanes from 48 to 43 to bring the 13-kilocycle mode of vibration outside the running range. This method has been adopted on a large scale and appears by measurement to give a marked reduction in the maximum stresses. It has not been tried long enough, however, for positive conclusions to be reached.

The assumption that the stresses are induced by aerodynamic forces acting directly on each bucket cannot account for the behavior of the buckets. A great deal of the energy passes between the buckets by way of the turbine disk. The device of damping one bucket with a similarly-tuned bucket near it was tried. This disclosed that, when one bucket was bowed, much energy was transferred from it to the next or to a well separated bucket provided the buckets were tuned to the same frequency. Testing this with strain gages showed that the disk was being stressed at the known frequency of the buckets in the majority of modes.

This opinion still awaits conclusions from further evidence, but the investigations have already shown that, in gas turbines as in steam turbines, the greatest bucket stresses are excited by the stator vanes immediately preceding the turbine stage. The same technique is applicable to the investigation of other modes of vibration but the cure may be different.

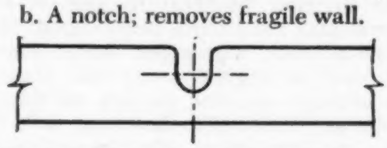
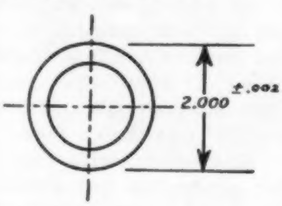
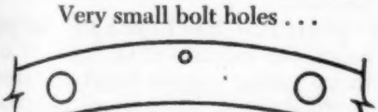
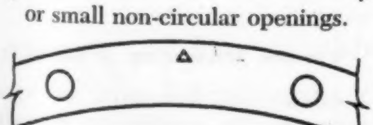
The author gratefully acknowledges the assistance of Denis A. Drew, chief of vibration department, Rolls-Royce Ltd., Derby, England, for information and illustrations used in this article.

They Say

"It may be that the Dreaded World War III has not started for the reason that we have the greatest stockpile of atomic weapons, the greatest industrial plant and the largest reserve of scientists. We must continue to match numbers with better equipment and training. But we cannot rely solely on this potential strength of ours. We and our Allies do not have a corner on scientific skill!"—CLIFT ANDRUS, *major general, U. S. Army.*

"Good employee relations—and where you find them you invariably find good personnel administrators—are not achieved by techniques alone, but by an underlying faith in the individual man—and a belief that sincerity, frankness, fairness and consideration will engender a response in kind."—HARRY M. NORDBERG, *vice president, Pitney-Bowes Inc.*

How to remedy common errors in gasket design

The fault	The reason	The remedy
Bolt holes too close to edge. 	Gaskets so designed are expensive to make as well as expensive to use. They break easily during stripping and center picking and are easily damaged in transit. Often such gaskets also demand careful handling during assembly.	a. An "ear"; strengthens gasket.  b. A notch; removes fragile wall. 
Metal-working tolerances applied to gasket thickness, diameter, length, width, etc. 	Close tolerances involve special dies, extra manufacturing operations, and special sorting and inspection. This delays deliveries and increases costs.	Specify realistic tolerances. In most cases, a *resilient* gasket is entirely satisfactory if held no closer than ± .010", even on metal parts that must be held to ± .002". Try standard or commercial tolerances before concluding that special accuracy is necessary.
Very small bolt holes . . .  or small non-circular openings. 	Centers from such holes probably require hand-picking. Because small holes are easy to miss, extra inspection must be employed. Naturally, this slows down gasket production and increases gasket costs.	Avoid hole sizes under 3/32" diameter. If hole is for indexing or positioning, it may be possible to change to a small notch. 

You'll find other helpful information on the design and use of gaskets in "Armstrong's Gasket Materials." This 24-page manual discusses subjects such as designing gaskets to reduce cost . . . designing flanges for efficient sealing . . . the effect of surface condition on gaskets, and many others.

You'll find, too, up-to-date information on Armstrong's various sealing and friction materials. Included are government and SAE-ASTM specifications. See this manual in Sweet's file for product designers. For a personal copy, write Armstrong Cork Co., Gaskets and Packings Dept., 5112 Arch Street, Lancaster, Pennsylvania.

Armstrong's *Gasket Materials*

Report on Materials

The materials situation is beginning to take on a consistent pattern, with few changes in the shortage picture. Several minor groups, currently less affected by defense needs, show a slight tendency toward being in better supply.

Metals, however, are consistently tighter, with only two important exceptions. Supplies of both sheet steel and strip have eased though this probably will be only a temporary move. Structural shapes, bars, heavy forgings and alloy steels have tightened further. Adequate scrap collection continues to be steel's most persistent problem.

Copper supplies are almost dangerously short. Two large strikes, extreme shortage in scrap supplies and continued low imports caused by international prices have made copper the most critical of all important production metals for both the immediate and the long-range outlook.

The suspension of tin purchases due to excessive prices has resulted in considerable reduction in industrial stocks of tin. Lead and zinc production has been hampered by strikes, reduced imports and inadequate scrap collections. Aluminum production also has suffered from strikes, and from scrap and water power shortages. Magnesium, with considerably smaller production but similar difficulties, has nearly maintained its position.

While still insufficient for essential needs, the supplies of all types of synthetic rubber except butyl are steadily improving. Two more important plastics have eased—phenolic resins and polyvinyl alcohol.

Factors Influencing Availability

Among the important factors determining the availability of various materials are the following:

Supply

Availability of materials
Sources—domestic or foreign
Transportation required
Production capacity
Manpower

Demand

Military requirements
Defense-supporting programs
Stockpiles
Domestic industries
Civilian economy.

List of Basic Materials and Alternates

In issuing the following list of critical materials (released October

29, 1951), the National Production Authority has adopted slightly different classifications for evaluating the supply situation. These are:

GROUP I: Materials in Group I are *insufficient for defense and essential civilian demands.* Alternates should be selected for these wherever possible. *"Most critical" items under I-A Metals are preceded by an asterisk(*).*

GROUP II: Materials in Group II are in approximate balance with *defense* and *essential civilian* demand. Expanded use of these materials should be avoided.

GROUP III: Materials in Group III are in fair to good supply. These materials should be used as alternates for those in Group I and II whenever possible.

Selecting Alternates

In order to conserve scarce materials, the NPA has suggested a procedure to be used in selecting alternates.

Because of their greater availability, alternate materials in Group III should first be considered in place of scarcer ones in Groups I and II. Where practical, consider "cross-substitution" of an entirely different type of material.

If no Group III choice is acceptable, provided poundage is small, select a material in Group II to replace one in Group I.

As a last resort, particularly in metals, even though both may be in Group I, use a large tonnage material like steel to replace a smaller tonnage one like copper.

Metals—Group I-A
(In short supply)

a—Nonferrous:
- *Aluminum
- Beryllium
- *Copper
- Germanium
- *Lead
- Magnesium
- *Selenium
- Titanium
- *Tin
- *Zinc

b—Precious:
- Iridium
- Osmium
- *Platinum

c—Ferrous alloying elements:
- *Cobalt
- *Columbium
- *Molybdenum
- *Nickel
- Tantalum
- *Tungsten

d—Ferrous:
- Bars, cold drawn:
  - Alloy
  - Carbon steel
- Bars and semi-finished, hot rolled:
  - Alloy
  - Carbon steel
- Castings:
  - Carbon steel

*Most critical.

VALVAIR
Diversatility
makes possible ANY CONTROL ASSEMBLY on a STANDARD VALVE BODY
—can give you the right VALVE for Any Air Control REQUIREMENT
KNOB
TREADLE
CYLINDER
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LEVER
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DIAPHRAGM
SOLENOID
FOOT
NATIONAL ACME DEPENDS UPON VALVAIRS FOR SPLIT-SECOND OPERATION
VALVAIR CORP.
All 9 control assemblies fit all 5 Valvair bodies in respective sizes.
Internal parts in respective sizes are completely interchangeable.
Spring return if required.
★ ★ ★
5 standard bodies: 2-way, 3-way, and 4-way open-end exhaust, 3-way and 4-way piped exhaust.
Valvairs control air, vacuum, water, oil or inert gas pressures up to 175 p. s. i. and tempertures to 140° F. Pipe sizes ¼" through 1".
No. 4 Copyright 1951 by Valvair Corporation
This well known manufacturer says:
"We MUST get complete dependability from air control valves on our Acme-Gridley bar machines. That's why we chose Valvairs."
Rely Upon Valvair
953 BEARDSLEY AVE. • AKRON 11, OHIO
Sales Representatives in Principal Cities Throughout United States and Canada

Iron alloy gray:
Heavy, over 3,000 pounds
Iron, malleable
Steel, low alloy
Castings, steel high alloy:
Corrosive-resistant
Heat-resistant
Die blocks
Forgings, heavy
Iron powder
Pig iron, low phosphorus
Pig iron, silvery
Pipe:
Seamless, all sizes
Welded, 4 inches and over
Plate, tin
Plates
Rope wire, galvanized
Shapes, structural
Sheet, galvanized
Strand wire, galvanized
Stainless steel:
Nickel-bearing
Tubing, seamless:
Alloy mechanical
Alloy pressure
Carbon, mechanical
Carbon, pressure

Metals—Group II-A
(In approximate balance)

a—Nonferrous:
Antimony
Bismuth
Cadmium
Calcium
Tellurium

b—Precious:
None

c—Ferrous alloying elements:
Chromium
Manganese
Silicon (except silvery pig iron)
Vanadium

d—Ferrous:
Forgings, medium
Pipe welded: 3 inches and under
Pig iron (other than in Group I)
Sheet (except galvanized)
Strip
Wire, drawn

Metals—Group III-A
(In fair to good supply)

a—Nonferrous:
Mercury

b—Precious:
Gold
Palladium
Rhodium
Silver

c—Ferrous alloying elements:
Boron
Titanium (ferro)
Zirconium

d—Ferrous:
Castings:
Gray iron (light and intermediate weights)
Forgings, small
Stainless steel:
Straight chrome
Tool Steel
Tubing, welded carbon, mechanical

Chemicals and Plastics—Group I-B
(In short supply)

Nylon, plastic type
Phosphate plasticizers
Polyethylene resins
Polytetrafluorethylene (Teflon)
Selenium compounds
Styrene
Thiokol-polymers

Chemicals and Plastics—Group II-B
(In approximate balance)

Alkyd resins

Ethyl cellulose
Melamine
Melamine resins
Phenolic resins
Polyvinyl acetate
Polyvinyl alcohol
Polyvinyl butyral
Polyester resins

Chemicals and Plastics—Group III-B
(In fair to good supply)

Amyl acetate
Cellulose acetate
Cellulose butyrate
Methacrylate
Polystyrene
Polyvinyl chloride
Urea resins

Miscellaneous—Group I-E
(In very short supply)

Asbestos:
- Chrysotile: Crude and spinning fibers
- Shingle and paper fibers
- Amosite

Graphite, natural:
- Crucible flake
- Madagascar flake

Graphite, artificial: Electrodes, anodes and special shapes
Graphite, Ceylon: High carbon amorphous lump
Mica:
- Muscovite block and film, good stained better
- Bookform splittings

Rare earths
Rubber:
- Guayule
- Natural, dry
- Synthetic

Talc: Indian block, lava grade

Miscellaneous—Group II-E
(In approximate balance)

Abrasives, synthetic:
- Silicon carbide
- Aluminum oxide

Mica:
- Phlogopite, block
- Muscovite block and film (stained and lower)
- Muscovite splittings

Paper
Paperboard
Quartz crystals (MBS Grades I and II)
Talc: Ground, including steatite

Miscellaneous—Group III-E
(In fair to good supply)

Asbestos, Chrysotile: Shorts and waste fibers
- Clays: Ball, fire and china

Rubber:
- Reclaimed
- Natural, latex

Copies of the complete *List of Basic Materials and Alternates* may be obtained from the nearest District or Regional Office of the Department of Commerce, or by writing Printing Services, Department of Commerce, Washington 25, D. C.

Acknowledgment

In connection with the October feature, "Designing with Modern Materials," we acknowledge with appreciation the assistance of the Polymer Corp., Reading, Pa., whose name was inadvertently omitted from the list of our collaborators on Pages 358 and 360.

Design Abstracts

(Continued from Page 170)

stress, and tapering towards the rim at a given value of the mean thickness would decrease the hub stress at the expense of an increased rim-stress. Over the range considered, these two effects approximately cancel at the rim, and they are additive at the hub.

Taper is primarily of importance for highly stressed couplings where the size of the disk is limited by the space available or the centrifugal stress, or where reduction of the bending stresses to the desired values would involve excessive disk-forging costs. For the lowest stresses at a given deflection, the disk thickness must evidently be as small as possible and will depend on the magnitude of the torque to be transmitted.

With a machined coupling and negligible torque, the minimum disk thickness is determined by machine-shop capabilities or by the general robustness of the coupling. It is assumed in this paper that the least permissible thickness is independent of the rate of taper. At given values of a and b, taper decreases the hub stress while the rim stress is increased; thus the best choice of taper is that which makes $p_{ra} = p_{rb}$.

For large torques, the minimum disk thickness is determined by the maximum permissible shearing stress. *Fig.* 2 shows the radial bending stresses in the form $p_r = KT/qa^3$ tons per sq in. per deg of skew. For given values of T, q, and a, taper can halve the stress which is obtained with the uniform thickness disk, by comparison at the best value of b/a in each case. There is no objection to tapering the disk more heavily to reduce the coupling stiffness, although near the optimum value of b/a there is little reduction in stresses.

Fig. 3 gives the disk stiffness in the form; applied moment $= kt_b{}^3$ ton-inches per deg of skew. This quantity depends only on the thickness and proportions of the disk, and is independent of the radial dimensions.

UMBRELLA DEFLECTIONS: The radial bending stresses at the hub and rim are plotted in the form $p_r = Kt_b/a^2$ tons per sq in. per inch of axial movement in *Fig.* 4, which generally reproduces the features of *Fig.* 1. For the uniform thickness disk, the least bending stress at the hub occurs at a slightly lower value of b/a, and

the ratio of hub to rim stress is rather less than for skew bending, which makes the advantage of tapering very thin disks rather less. For high torque transmission at the respective best values of b/a, the maximum stress in the uniform thickness disk is about 1.6 times greater than in the disk tapered to make $p_{ra} = p_{rb}$. The disk stiffness is plotted in *Fig.* 5 in the form: axial load $= kt_b{}^3/a^2$ tons per inch deflection.

FORM OF TAPER: Since the form of taper $t = t_b\ (r/b)^{n/3}$ has been chosen solely to facilitate computation, it is open to question whether, for given design limitations, some other form of taper would give greater permissible deflections.

For the radial bending stress only, the maximum deflection is obtained from a given size of disk with a given hub thickness, if the stress is everywhere made equal to the maximum permitted value. Although this distribution is not attainable in practice (since the other stresses must be considered) it is a yardstick against which other forms of taper can be judged.

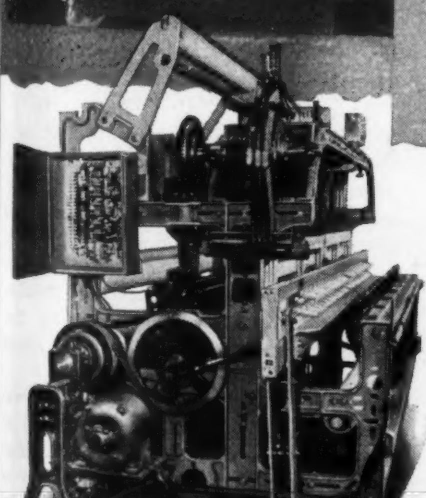
Some curves of the distribution of radial stress in the case of skew bending are given for various values of b/a and n in *Fig.* 6. The form of taper is reasonably close to the ideal, for values of b/a up to about 0.3, if n is chosen to make p_{ra} and p_{rb} equal. At greater values of b/a, however, the departure from the ideal form increases progressively.

Improvement Is Possible

An improvement on the disk form may be obtained, to a first approximation, by thinning where the stress—according to *Fig.* 6—is too low. Thus when $b/a = 0.5$, instead of $n = -2.6$ which makes $p_{ra} = p_{rb}$, the disk should be made more nearly to the form in which $n = -4.0$, but should be progressively thickened over the outermost 15 per cent of the annulus to give a rim thickness some 25 per cent greater than the theoretical. This would reduce the maximum bending stress to roughly 75 per cent of the maximum stress for the form $t = t_b(r/b)^{n/3}$. The curves of *Fig.* 6 also indicate that the stresses shown in *Fig.* 1 are the greatest occurring anywhere in the disk providing the rate of taper is less than that required to give $p_{ra} = p_{rb}$, even to a value of b/a as low as 0.05, but that at larger values of $-n$ the radial bending stress may increase outward from the hub.

One other form of taper which requires special mention is the straight conical taper. This will always be cheaper to produce than a curved

FOR VIBRATION INSURANCE



The adjustable throw cranks of the Fletcher High Speed Ribbon Loom are accurately and securely held in position by FLEXLOC Nuts. These cranks are subject to heavy loads at speeds of 200 to 225 RPM. In this difficult application FLEXLOCs have been successfully used since 1946.

ON *Fletcher* LOOMS

The crankshafts on Fletcher High Speed Narrow Fabric Looms *must stay tight*—that's why FLEXLOCs are used to fasten them. FLEXLOCs not only provide *vibration insurance*, but they *promote uninterrupted production* and *cut maintenance costs.*

FLEXLOC also feature: *one-piece, all-metal construction*—nothing to work loose or forget and no serious temperature problem; and *resilient, automatic locking sections* — processed by our patented method to provide closely controlled torques.

Convince yourself of the VIBRATION INSURANCE provided by FLEXLOC! Test-run them on your own product, let us know what size you need and *we'll send samples* with our latest literature promptly.

SPS

STANDARD PRESSED STEEL CO.
JENKINTOWN 18, PENNSYLVANIA

surface, and is probably the only alternative to a uniform thickness disk if a profiling lathe is not available. For given values of a, b, t_a and t_b, the straight cone is thicker in the center of the annulus than the form $t = t_b(r/b)^{n/3}$, and the hub and rim stresses are therefore higher than in that instance. The departure from the listed values is evidently greatest where the disk surface is most curved, that is, for large values of $-n$ and small values of b/a.

The stress distributions for umbrella deflections have not been investigated, but the arguments concerning skew deflections are generally applicable.

From a paper entitled "The Design of Flexible Disk Misalignment Couplings," presented before the Institution of Mechanical Engineers. Copies of the complete paper may be obtained at no charge from the Institution, Storey's Gate, St. James' Park, London, S. W. 1, England.

Aircraft Nuclear Propulsion

By M. C. Leverett
General Electric Co.
Oak Ridge, Tenn.

ONE pound of uranium-235 will liberate heat on undergoing fission equivalent to the energy liberated by burning 1,700,000 pounds of gasoline. It is at once evident that if a means can be found for converting the energy of nuclear fission into thrust that aircraft can fly for very long times on very small amounts of fuel.

One of the basic principles of nuclear energy is that the energy of fission is manifested as heat. That is, a nuclear reactor is primarily a source of heat which must be converted into thrust or into mechanical work in more or less conventional ways. Hence, in any nuclear power plant—whether it is for an aircraft, a naval vessel or for the generation of electricity on the ground—there will be a reactor and heat machinery. In the aircraft the heat machinery is the propulsion system. Secondarily, and somewhat unpleasantly, the reactor is a source of radioactivity; hence, there will also be a shield.

PROPULSION MACHINERY: There is scarcely a single type of aircraft propulsion machinery which has not been proposed for incorporation in a nuclear power plant for aircraft. One obvious proposal is that propellers be used, driven by turbines which are in turn run by expanding through them vapor such as steam or air, heated in the reactor. A variation of

this scheme would be to extract the heat from the reactor by some liquid coolant other than the vapor or air and transferred to the vapor or air in an external heat exchanger or boiler.

Another fairly obvious proposal is that the reactor should directly or indirectly take the place of the combustion chambers of a conventional turbo-jet engine. Here again, the heat might be extracted from the reactor directly by the air or indirectly by other coolants, such as liquid metals, and transferred to the air outside the reactor.

Ducted fans driven by turbines, operated in turn by vapor or air heated in the reactor, have been suggested. Obviously, the reactor might also take the place of the combustion apparatus in a ram-jet propulsion system. It has also been proposed that a compressor-jet type of propulsion system be used, with the compressor driven by vapor or hot air from the reactor and the heat supplied to the air by a heat exchanger through which the reactor coolant passes.

Choice Not Easy

In all cases, except that of the ram-jet and other direct air cycles, it is required that heat be transported in a coolant from the reactor to the propulsion machinery. In making a choice among the various types of propulsion machinery which have been suggested, the designer must perform detailed and careful analyses of many different possible combinations.

Some of the problems which confront him are so obvious that they may be mentioned here. For example, if a propeller type propulsion system is chosen, the hot fluid from the reactor must be piped to the turbines which drive the propellers; these in turn must be mounted on the wings. Thus each propeller must be provided with its own reactor, or hot fluids must be piped around the airplane from a central reactor heat source. Any reactor coolant will undoubtedly become somewhat radioactive in passing through the reactor, and this alternative hence is not attractive. On the other hand providing each propeller with its own reactor is not easy either, for two reasons. First, the weight of a reactor, with its shield, is very large; more than one reactor and shield therefore is highly undesirable from a weight standpoint. Second, two reactors per airplane would require more than twice the fuel investment of one reactor and a low fuel investment per airplane is desirable.

REACTOR: The design of the reac-

tor will be greatly influenced by the coolant chosen. However, the basic principle upon which the reactor operates is the same regardless of the coolant. This principle is as follows: The reactor may be thought of as a more or less cylindrical body throughout which a fissionable material such as uranium-235 or plutonium-239 is distributed. The reactor also contains passages for the flow of the coolant necessary for the removal of the heat and also usually contains a material which is called a *moderator.* The reaction starts with the capture of a neutron by a nucleus of, say, uranium-235. Since neutrons are present in small concentration in the atmosphere everywhere, this serves to start the reaction. Immediately after capture of the neutron the U-235 nucleus disintegrates with the liberation of two to three neutrons and 2 atomic nuclei (fission fragments) both smaller than the original nucleus. Most of the energy of fission is carried off by the fission fragments; this energy is imported to the material into which they are cast and appears as heat. Gamma rays and beta rays also are given off in the fission process.

The two to three neutrons given off are ejected into the body of the reactor and may undergo one of three different fates. (1) They may escape from the reactor entirely and be captured outside it by some parasitic nucleus in the structure of the shield or its surroundings. (2) They may be captured by some of the nonfissionable materials in the reactor itself. (3) They may be captured in another U-235 nucleus, following which additional neutrons will be given off. If we can design the reactor so that about 40 per cent of the neutrons given off in fission are captured in other fissionable nuclei in such a way as to cause fission there, the reaction will continue indefinitely until the fissionable nuclei are used up.

Loss Must Be Minimized

The basic problem of reactor design is to reduce to acceptably low values the first two methods of loss of neutrons; that is, leakage from and parasitic capture in the reactor. Leakage may be counteracted to some extent by surrounding the reactor with a neutron reflecting material which scatters but does not capture the neutrons. For example, graphite and beryllium oxide are known to be good reflectors. Excessive capture of neutrons in nonfissioning nuclei in the reactor may be avoided by eliminating from the reactor atomic species which have

a strong tendency to capture neutrons or, in the language of the nuclear physicist, have a high neutron-capture cross-section. Unfortunately, it is not always easy to do this because some of the materials which are most siutable for use as reactor structure, and without which the reactor will not support itself, have rather high capture cross sections. These are thus poisons for the nuclear chain reaction although essential for the mechanical stability of the reactor.

Obviously, we may increase the fraction of the neutrons which are absorbed in U-235 nuclei by increasing the proportion of U-235 present in the reactor. Unfortunately, this increases the amount of fissionable material invested in the reactor. Since such material is extremely precious, it is desirable to keep its quantity to a low value. We usually, therefore, resort to the device of introducing into the reactor a *moderator.*

Moderator Reduces Loss

A *moderator* is an element of low atomic weight and low capture cross-section for neutrons. Because of its low atomic weight a neutron striking it loses a relatively large fraction of its energy in each such collision. Because of its low capture cross-section, it does not capture many of the neutrons which strike it. After the neutrons are thus slowed down or moderated, their capture by the fissionable material in the reactor becomes much more probable since the cross section for capture of low energy neutrons is higher than that for high energy neutrons. Typical moderators are graphite, ordinary water, heavy water, beryllium and beryllium oxide.

The control of the chain reaction is in principle exceedingly simple. One of the most direct means of control is to arrange an absorbing rod so that it can be inserted into the reactor or withdrawn from it. If the rod is withdrawn from the reactor, it will absorb a smaller number of neutrons than before. If, in its original position, the rod was absorbing that number of neutrons which made the reactor just critical, (that is, neither rising nor falling in power) then withdrawal of the rods will create a slight excess of neutrons in the reactor and the power will begin to increase.

Other methods of control have been proposed also. For example, in a reactor which has a reflector, removal of part of the reflector will allow the leakage of more neutrons than before. This will decrease the reactivity and constitutes a method of control. Also, removal of part of the

moderator or of some of the fuel itself from the reactor will decrease the reactivity, and these expedients may also be used as control mechanisms.

It is evident that the control of the reactor is an important matter, not so much because of the remote possibility that the reactor might turn itself into a low grade atomic bomb, but because if the power of the reactor fluctuates without a corresponding fluctuation in the heat removal capacity of the heat transfer system, the reactor inevitably will heat up. Overheating, if sufficiently severe, can cause accelerated corrosion, warping or even melting of parts of the reactor. Evidently too, it is important that the reactor not be operated without a flow of coolant through it since this certainly will result in serious damage if not destruction of the reactor.

Safety Demands Shield

SHIELD: Although most of the energy of nuclear fission appears as kinetic energy of the two fission fragments, and this kinetic energy in turn appears as heat in the fuel elements, a substantial portion of the energy of a reactor appears as kinetic energy of the neutrons and as ionizing radiation, such as gamma rays and beta rays. The neutrons and gamma rays, if allowed to escape with complete freedom from the reactor, would make it necessary for human beings to stay at a distance of more than a mile from a high powered reactor while in operation. Moreover, since the fission products themselves are radioactive and continue to emit gamma rays even after the chain reaction has been stopped, it would not be possible to approach the reactor very much closer than this even after it had been shut down. It is clear that a shield must be provided.

The basic requirements of the shield are dictated by the two basic types of radiation which it is desired to stop. The neutrons are slowed down most effectively by light atoms such as hydrogen, and moreover are more easily captured after being slowed down. For this reason an effective shield will contain light atoms such as hydrogen, which also is a good slow neutron absorber. Gamma rays, on the other hand, are degraded in energy and stopped best by heavy elements such as lead. Hence, the shield normally will contain heavy elements also. It is clear that a mixture of light and heavy elements arranged in the most strategic fashion will be desired. The detailed solution of this problem is complicated.

Another point of importance is that

not only must the shield prevent escape of radiation from the reactor to the desired degree but also it must be capable of admitting and emitting the coolant which carries the heat away from the reactor. This means that ducts must pierce the shield and we are then confronted with the problem of leakage of radiation through these ducts. Generally speaking, gamma rays and neutrons travel in straight lines. However, under certain conditions they can be scattered or reflected around corners or curves.

Shield Requires Large Plane

SHIELD WEIGHT: The shield will be the heaviest single object aboard the aircraft. Early published estimates of shield weight placed the minimum shield at 50 to 100 tons, without any provisions for removal of heat. From this it is evident that a large aircraft will be required to carry a weight of this magnitude even though the aircraft need carry little or no chemical fuel. To a first approximation one may balance off the weight of the shield against the weight of the fuel load which would be carried in the large modern aircraft, since the shield and the reactor which it contains essentially replace the fuel load. The fuel loads of modern aircraft range up to the neighborhood of 75 tons or more. If the early estimates of shield weight are nearly correct, it is evident that the weight of the shield plus the reactor is not grossly different than that of the fuel which can be carried in a large conventional aircraft. However, every effort must be made to keep down the weight of the shield and the reactor. One obvious way to do this is to make the reactor small so that the shielded volume is kept small. This in turn restricts the amount of cross-sectional free flow area through which coolant may pass through the reactor and increases the pressure drop. Moreover, as the reactor diameter decreases it usually is found that more fissionable material is required. This is undesirable. There is therefore a balance to be struck between the benefit of small shield weights resulting from decreased reactor size and the disadvantages resulting therefrom in smaller free flow area for coolant flow and larger fissionable material investment required.

BALANCE AND STRUCTURE: The existence of a large concentrated weight such as the shield and the reactor at one point in an aircraft, makes it necessary to redesign the structure of the aircraft to accommodate this weight. Although large aircraft are designed for very large

(*Continued on Page* 235)

There Is A Kunkle Valve For Almost

STEAM POP-SAFETY VALVES

FIGURE 1

A. S. M. E. standard. N.B. approved. Max. set pressure, 125 p.s.i., adjustable. ⅜" to 4" N.P.T. male inlet. Top outlet. Available. 150 or 300 lb. M.S.S. 1½" to 4" flange inlet. All bronze.

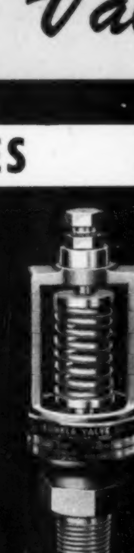


FIGURE 40

Max. set pressure, 500 p.s.i. at 850°F. Adjustable. Two sizes, ½" and ¾" N. P. T. male inlet. Top outlet. Stainless steel body and disc. Stainless or Inconel spring. Sentinel warning-relief.

FIGURE 2

A. S. M. E. standard. N.B. approved. Max. set pressure, 125 p.s.i., adjustable. ⅜" to 4" N.P.T. male inlet. Side outlet, ¾" to 4" female. Available. 150 or 300 lb. M.S.S. 1½" to 4" flange inlet. All bronze.

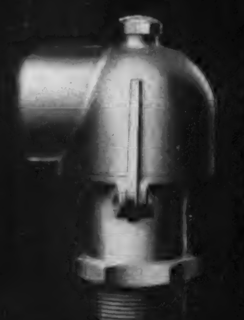


FIGURE 31

A. S. M. E. standard. N.B. tested. Set pressures to 15 lbs., 189 to 6700 lbs./hr. steam. ½" to 4½" N. P. T. male inlet. Female side outlet. Meets all code and states' requirements. All bronze.

FIGURE 23-S

A. S. M. E. standard. N.B. approved. Max. set pressure, 350 p.s.i., adjustable. ½" to 4" N.P.T. male or female inlet. Side outlet. ¾" to 4" female. Available. 150 or 300 lb. M.S.S. ¾" to 4" flange connections. All bronze.

FIGURE 34

A. S. M. E. standard. N.B. certified. Set pressure, 10 or 15 lbs. ¾" to 3" N.P.T. male inlet. Top outlet. For low pressure steam heating boilers. All bronze.

FIGURE 83

A.S.M.E. tested. N.B. certified. Max. set pressure, 300 p.s.i., adjustable. ¾" to 3" N.P.T. male inlet. Side outlet. 1¼" to 4" female. Available. 150 or 300 lb. M.S.S. 1½" to 3" flange inlet. All bronze.

FIGURE 36

A. S. M. E. standard. N.B. certified. Set pressure, 10 or 15 lbs. ¼" to 3" N.P.T. male inlet. Side outlet. For low pressure steam heating boilers. All bronze.

FIGURE 90

A.S.M.E. tested. N.B. certified. Max. set pressure, 250 p.s.i. 1½" to 6" A.S.A. 250 R.F. inlet. Outlets flanged or screwed. Cast iron, optional bronze or s/s trim.

FIGURE S68

Max. set pressure, 600 p.s.i. Adjustable. Max. temp. 850° F. ½" to 3" N.P.T. female threaded or std.-flange inlet. Top outlet. Alloy steel with s/s trim.

FOR QUICK ESTIMATION OF YOUR VALVE NEEDS, REVIEW THE FOLLOWING SELECTION CHECK POINTS:

1. Type of service and code requirer
2. Pressure setting and capacity.
3. Size and type of connections.
4. Body and trim material.
5. Special needs of completed unit.

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LIQUIDS: WATER, OIL, RES

FIGURE 10

500 p.s.i. max. p sure. Adjustable. to 3" N.P.T. mal let. ½" to 3" fem side outlet. A able with h wheel as Figur All bronze.

FIGURE 11

100 p.s.i. max. pressure. Adjustable. ¼" to ¾" N.P.T. male inlet. Female side outlet. All brass and/or bronze.

FIGU

FIGURE 19

350 p. s. i. maxim pressure. Adj able. ½" to 4" N male inlet. ½ 4" female side let. Hand wheel ready pressure v ation or release. bronze. Fig. with nickel disc pressures to 1 p.s.i.

FIGURE 20

350 p.s.i. maximum pressure. Adjustable. ½" to 4" N.P.T. male or female inlet. ½" to 4" female side outlet. All bronze. Fig. M20 with nickel disc for pressures to 1200 p.s.i.

FIGU
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CONN

WRITE FOR COMPLETE CATALOG WITH CAPACITY DATA

S

KUNKLE SAFETY AND RELIEF VALVES

SERVICE RECOMMENDATIONS

FIG. NO.	MATERIAL		*MAXIMUM PRESSURE Lbs. per Sq. Inch			A. S. M. E. CODES			National Board Certified	Mass. Approved	Canadian Approved	NAVY SPEC. NO. 45V26
	BODY	TRIM	Steam	Air Gas Vapor	Liquids	Power Boiler	Heating Boiler	Unfired Vessel				
1	Bronze	Bronze	125			•			•			
1A	Bronze	Bronze		250				•	•		•	
2	Bronze	Bronze	125			•			•		•	
9	Bronze	Bronze			500							
10	Bronze	Bronze			500							
11	Brass	Brass			100							
14	Brass	Brass		225								
19	Bronze	Bronze			350							
M19	Bronze	Nickel Alloy			1200							
20	Bronze	Bronze			350							
M20	Bronze	Nickel Alloy			1200							
22	Bronze	Bronze	350	350				•				
M22	Bronze	Nickel Alloy	350	1200				•				
23A	Bronze	Bronze		350				•	•	•	•	
23S	Bronze	Bronze	350			•		•	•		•	
28	Brass	Synthetic		200				•				
29	Brass	Brass		225				•			•	
31	Bronze	Bronze	15				•		•		•	
34	Bronze	Bronze	15				•		•			
36	Bronze	Bronze	15				•		•		•	
39	Brass	Brass		225				•		•		
40	St. Steel	St. Steel	500					•				
48	Brass	Brass		225				•				
50	Bronze	St. Steel			3300							
53	Bronze	St. Steel		3300				•		•	•	
S68	Alloy Steel	St. Steel	600	600								
71	Cast Iron	All Iron		250	400							
82	Bronze	Bronze	300	300		•		•	•	•	•	
83	Bronze	Bronze	300	300		•		•	•	•	•	
90	Cast Iron	Bronze	250			•		•	•	•	•	
218	Cast Iron	Bronze			240							
12-250	Steel	St. Steel		3000	3000							
S12-250	St. Steel	St. Steel		3000	3000							

DETAILED INFORMATION ON KUNKLE AND KUNKLE-STAR NAVY TYPE A-1, CLASSES A, B AND C VALVES IN ACCORDANCE WITH SPECIFICATIONS WILL BE FURNISHED UPON REQUEST.

*Complete Capacity Data Available In Kunkle General Catalog

• Facilities of the Kunkle engineering department are at your service for assistance in correct specification and application of Kunkle valves for your manufactured product or assembly. Where unusual service problems indicate a special valve, Kunkle Valve engineers will prepare cost estimates.

Kunkle Valve Company, now the manufacturer of many items formerly made by Star Brass Mfg. Co. of Boston, is pleased to announce that these products are immediately available as KUNKLE-STAR safety and relief valves. Supplementing the regular line of Kunkle safety and relief valves, they permit us to render more complete service to the trade for chemical, paper making, oil refining and related industries, as well as for Naval and Marine applications.

FOR COMPLETE INFORMATION WRITE OR TELEPHONE

LITHO IN U.S.A.

KUNKLE VALVE CO. 101 SO. CLINTON ST. **FORT WAYNE, IND.**

(*Continued from Page 230*)

gross weights, this weight is usually distributed over the wing and throughout the fuselage. Concentrating the weight in the fuselage greatly increases wing bending moments and necessitates structural redesign in many cases.

Landing Weight Greater

LARGE LANDING WEIGHT: The fact that only a small amount of the fuel is consumed in flight means that the gross weight of a nuclear aircraft will be approximately the same on landing as on take-off. First, the landing gear must be made strong enough to take the higher gross landing weight. Second, the landing speed is increased and there may be a change in landing attitude which possibly could require changes in the landing gear, or in tail clearance angle requirements.

HEAT TRANSFER: The very essence of a nuclear power plant is the transfer of heat from the reactor to the propulsion machinery. The requirements for small size and high power density placed upon the aircraft reactor push the heat transfer designer to the limit of his knowledge. He must avoid hot spots in the flow system, he must have good flow distribution and he must know exactly how the power is distributed in the reactor so that he can supply the right amount of coolant to each part of it. Solution of these problems requires a great deal of detailed analysis and experiment. For example, consider the cooling of a surface beneath which U-235 is located in a reactor. The rate of heat generation is independent of the local temperature; thus if the surface be deprived of its coolant, it will at once rise in temperature until it melts or disintegrates. The reactor is like a heat exchanger to which heat is constantly supplied whether it is taken away or not; only by maintaining the flow of coolant can trouble be avoided.

Minimum Critical Mass Needed

FISSIONABLE MATERIAL INVESTMENT: The desirability of keeping the quantity of fissionable material in the reactor small has been mentioned previously. It is obvious that this is desirable. However, the chain reaction will go in the reactor only so long as there is present a certain minimum quantity of fissionable material called the *critical mass*. As soon as the reaction has consumed so much fissionable material that the mass drops very slightly below the critical mass, the chain reaction dies and cannot be started again with-

out adding more fissionable material. Moreover, the products of fission remain in place in the fuel elements and eventually must be removed. This makes it necessary to remove the remaining fuel from the reactor, purify it and prepare it for reuse. The amount of uranium which may be tied up in the reprocessing activities may easily exceed that which is tied up in the reactor proper. Thus, the uranium investment is not simply the amount of uranium carried aboard the aircraft but also that which is on the ground in various stages of preparation for use.

Material Properties Deteriorate

RADIATION DAMAGE: Internuclear collision between neutrons and the nuclei of materials used as structures or as moderators in the reactor, or between fission fragments and other nuclei, result in dislocation of the nuclei with which collision occurs. While it is not definitely known how great an effect these dislocations have it is known that the properties of the materials in which they have occurred undergo a change. Usually this change is in a detrimental direction. For example, a decrease in thermal conductivity may occur, thus making the heat removal problem even harder. Or, other equally critical properties may deteriorate.

Some liquids or gases which might be proposed as reactor coolants are decomposed by radiation, and hence are not usable. Organic compounds are particularly susceptible, and even outside the zone of most intense radiation in the reactor ordinary lubricants turn tarry or even solidify. Lubricated machinery hence may not be used in such locations. Electrical insulation, on prolonged exposure to radiation, breaks down and disintegrates or loses its effectiveness.

MATERIALS: One of the most important problems in reactor technology today is the finding and development of materials adequate for use in reactors which are proposed for production of power in one form or another. The combined effects of high temperature, corrosion by various coolants, radiation damage, thermal stresses, and mechanical stresses can be extremely serious in some cases. The aircraft reactor presents these problems to an unusual and critical degree. For example, a difference of 100 F in permissible maximum reactor temperature can easily produce a 15 per cent difference in thrust output of the power plant. High temperature materials are therefore a prime necessity.

OUTLOOK: In many respects the propulsion of aircraft is an ideal

use for nuclear energy. Here to a higher extent than in any other application the advantages of a highly concentrated source of heat can be used to good result. Although the goal of producing a nuclear powered aircraft is an admittedly ambitious one it is only such high-performance premium uses of energy which can today justify the consumption of as rare a resource as uranium-235 or plutonium-239. Moreover, it is inescapable that a development of this type has great military significance.

In recent months the government has announced that the nuclear aircraft program is entering a new phase. In this new phase the Aircraft Gas Turbine Dept. of the General Electric Co. has been given the responsibility for the propulsion system and the Consolidated Vultee Aircraft Corp. is to supply an airframe.

From a paper presented before the Chicago section of the Institute of the Aeronautical Sciences on October 4, 1951.

Shell Molding

By Bernard M. Ames
Material Laboratory
New York Naval Shipyard
Brooklyn, N. Y.

BASICALLY, the shell molding method utilizes the thermosetting properties of phenolic resins to provide a bond material for silica grains in the construction of a mold. The use of urea and phenolic resins is by no means novel in the production of sand cores and molds. However, shell molding techniques are unique in that neither temper water nor additional bond materials are employed.

Sound principles of gating and heading cannot be ignored in this, or for that matter, any other casting process if castings free from objectionable internal defects are to be manufactured. I would say, however, that with the exception of the aluminum-base alloys—gray iron, malleable and ductile iron are more compatible with shell molds than any of the other commercial alloys.

The shell molding process can be considered a precision casting process. It is generally thought of as being midway between sand casting and the lost-wax technique. However, I venture to say that if castings the size of those made in shell molds were made by the lost-wax process, no greater degree of accuracy would be obtained. In malleable iron, tolerances of 0.003 in. per in. are commercially feasible on fairly large castings. In one malleable foundry producing ammunition shells in ductile iron by the shell molding process 25 shells chosen at random varied in

weight, in the as-cast condition, between 11.09 lb and 12.04 lb. If the 11.09 lb casting were eliminated (and it was rejected), the variation in weight between the other 24 was 0.33 lb.

The apparent stability of shell molds with regard to resistance to deterioration and moisture absorption, coupled with their structural strength and lack of dimensional change make them particularly suitable for storage over indefinite periods. Consequently it may not be impractical to consider the storage of large quantities for critical casting work or the shipment of molds between plants, thus reducing duplication of master pattern equipment. Shell molds also have a high degree of permeability which is apparent by the ease with which smoke can be blown through them. If a backing material of high permeability is utilized, the gases generated from the decomposing organic binder are adequately vented with very little back pressure. This, coupled with low frictional losses due to the smooth mold face, permits the running of sections which normally would be a problem in conventional sand molds.

Process Can Be Mechanized

Favorable opportunities exist for a complete mechanization of the molding system on high production runs. Perhaps one of the outstanding advantages of this process is the fact that unskilled labor may be employed.

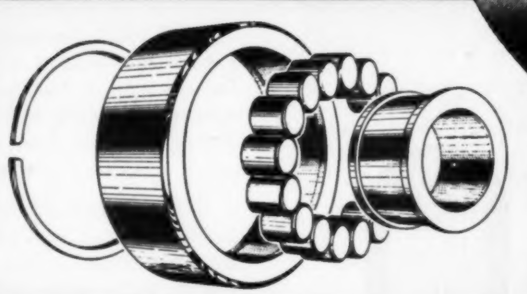
To date we have found that in the aluminum-base alloys, and bronzes, physical properties and internal soundness are comparable if not slightly superior to green sand practice. The same trends have been noted industrially for malleable and ductile iron.

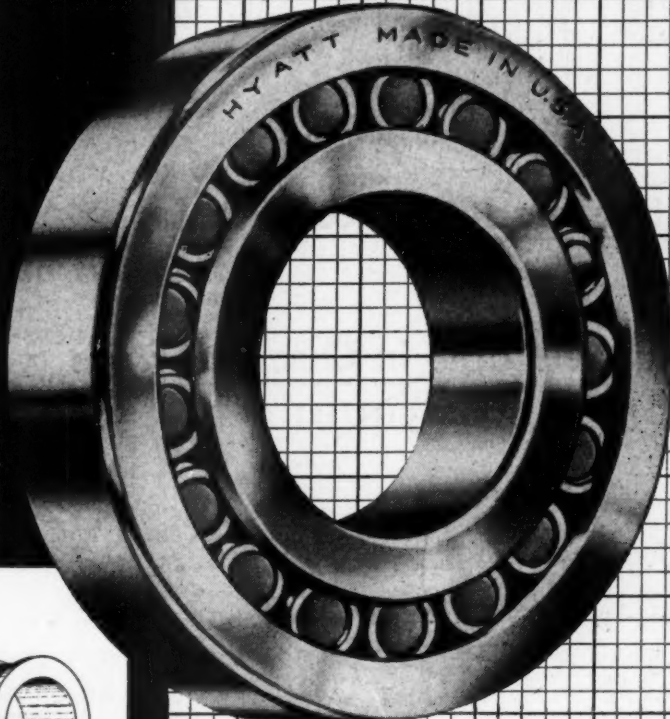
From an overall cost viewpoint obviously every job is not suited for the shell molding process. For one thing, as long as metal patterns are still a requirement, tooling costs are high and several patterns and core boxes are required. Hence, the necessary volume is a basic requirement. Second, the design of the casting must lend itself to a suitable parting and gating and heading arrangement. Third, and possibly the most important factor, is how much will be saved. No general rule for cost comparison with sand castings can be derived. Each casting must be examined on its own merits. The greatest economies to be gained obviously will be in the cleaning room and in the machine shop.

From a paper of the same title presented before the 125th Anniversary Meeting of the Malleable Founders' Society in Cleveland, September 20-21, 1951.

A High Capacity Full Complement Bearing...

HYATT HY-LOAD





THE U-YM type of Hyatt Hy-Load Roller Bearing is non-separable, with a full complement of rollers for maximum capacity, and flanged race construction to permit these bearings to locate the shaft endwise or accommodate light or intermittent thrust in one direction. Used in pairs, they can locate the shaft in both directions or carry light thrust from either direction.

The non-separable types of Hyatt Hy-Load Bearings, such as the U-YM, are made for applications where the bearings must be assembled as a complete unit.

* * *

The U-YM, or some other type of Hyatt Hy-Load Bearing may be just the right one for your machine design. Write for your copy of Catalog 547 for complete information about the Hy-Load line of Hyatt Roller Bearings. We will be glad to send one to you. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

News

OF MANUFACTURERS

A SPECIAL sample mold service for foundries interested in the resin-sand shell molding process has been announced by the plastics division of **Monsanto Chemical Co.**, Springfield, Mass. The new service provides foundries with an opportunity to obtain a sample mold made from shells of Resinox phenolic resins and sand from patterns sent in to Monsanto. Instructions have been prepared covering pattern specification, and foundries are urged to request copies of these instructions before preparing patterns for samples. The company's recently acquired plant in Addyston, O., will begin production of Resinox next year, providing greater service to foundries in the East, Midwest and far West.

♦

Lepel High Frequency Laboratories Inc., manufacturer of induction heating equipment, has moved into a modern new building at 55th St. and 37th Ave., Woodside, L. I., N. Y.

♦

A new aluminum smelting plant at Rockdale, Tex., is being constructed by **Aluminum Co. of America**, Pittsburgh. It is expected that the plant will be in partial operation late next year. Production capacity will be approximately 170,000,000 pounds annually when full operation is reached.

♦

Prime and subcontracts for the manufacture of parts for light and medium tanks have been awarded to the Memphis, Tenn., plant of Mechanics Universal Joint division of **Borg-Warner Corp.**, Chicago. The tank parts will be made in a new 30,000-sq ft plant which is now under construction.

♦

Raybestos-Manhattan, Inc., Passaic, N. J., has announced that production has started in its new Wabash division plant, which was constructed to manufacture sintered-metal products for the defense program.

♦

The **American Machine and Foundry Co.** radial arm saw manufacturing subsidiary, **DeWalt Inc.**, Lancaster, Pa., has purchased the complete Monarch woodworking machinery line of American Saw Mill Machinery Co., Hackettstown, N. J. The products acquired by DeWalt include a large radial saw, small radial saw, planer, bench saw, mortiser, jointer and band

saw. The parent company also purchased **Sterling Engineering Co. Inc.**, Laconia, N. H., manufacturer of electrical relays of the type used by the Armed Forces.

♦

Willys-Overland Motors Inc. has been granted a $10,000,000 facilities contract to expand by 60 per cent present steel and aluminum forging capacity at its Toledo, O., plant. New equipment to be used in manufacturing jet engine parts and other aircraft forgings, will be installed.

♦

A ten-fold increase in production of complete rocket motors for surface-to-surface missiles will be undertaken by **Ryan Aeronautical Co.**, San Diego, Calif., as a result of orders received from **Firestone Tire and Rubber Co.** of Los Angeles.

♦

The Tocco division of **The Ohio Crankshaft Co.**, Cleveland, has announced plans for its second "Economy in Production" contest. Contestants for the $3000 prize money must submit descriptive articles dealing with increasing production and/or decreasing cost with Tocco, and must describe actual installations of this induction heating equipment. Entry blanks may be obtained by writing the company.

♦

C. A. Norgren Co., Denver, has moved from 222 Santa Fe Drive to its new, modern plant in Englewood, Colo. The new plant is more than two and one-half times the size of the old one.

♦

The Economy Pump division of **Hamilton-Thomas Corp.**, Hamilton, O., is being consolidated with the **C. H. Wheeler Manufacturing Co.**, Philadelphia, another division of the corporation. Production, engineering and sales departments of Economy are being moved from Hamilton to the Philadelphia plant, and Economy pumps will henceforth be known as Wheeler-Economy pumps.

♦

The formation of six new operating divisions has been announced by **General Electric Co.** These include the turbine division and the motor and generator division, with headquarters at Schenectady, N. Y.; transformer and allied products division, with headquarters at Pittsfield, Mass.; measurements and industrial products division, with headquarters at Lynn, Mass.; switchgear and control division, headquartered at Philadelphia; and the component products division, Fort Wayne, Ind. Together with the recently formed defense products di-

vision, the new divisions include the majority of the departments which constituted former large apparatus and small apparatus divisions. General Electric has also announced the construction of a 250,000-hp wind-tunnel drive capable of creating supersonic blasts of air. Part of an order placed by the National Advisory Committee for Aeronautics, the giant drive will be installed at the Lewis Flight Propulsion Laboratory in Cleveland. It will be used to test aircraft power plants in the ramjet, gas turbine and rocket categories.

♦

The Rotex Punch Co., Oakland, Calif., manufacturer of the Quick Change turret punch press, has opened a second plant at 5215 East 12th St. in Oakland. The company will add a new power model punch press to its line after the first of the year.

♦

A new manufacturing plant is being constructed by **Benchmaster Manufacturing Co.** in Gardena, Calif. The first unit will provide 20,000 sq ft of floor space on what will eventually be a five-acre development.

♦

Announcement has been made of the 1951-52 prize competition and program of awards of **Eutectic Welding Alloys Corp.,** Flushing, N. Y. The competition, open to engineers, metallurgists, researchers, instructors, welders, students and all others qualified, features two categories: Category A for papers on "Welding Engineering and Theory," and Category B for papers on "Practical Welding Applications."

♦

The Lincoln Electric Co. recently moved to a new, modern plant at 22801 St. Clair Ave., Cleveland 17, O.

♦

By constructing a new laboratory building and by taking over part of an existing factory building, **United Lacquer Manufacturing Corp.** will triple its research facilities in Linden, N. J. In addition to research on finishes and protective coatings, special development projects also will be instituted in behalf of the textile printing, laminating and plastics industries.

♦

Baldwin-Lima-Hamilton Corp., Eddystone, Pa., has announced that on or about January 1, 1952, the sales, engineering and manufacturing activities of the Whitcomb Locomotive Co., a wholly-owned subsidiary located at Rochelle, Ill., will be transferred to the Eddystone plant. The Whitcomb plant will be utilized to provide space for the expansion of the manufactur-

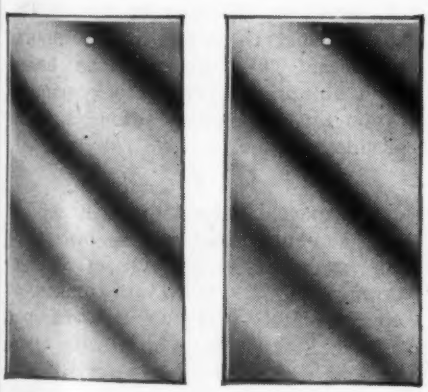
ADVERTISEMENT

Clear Coatings for Zinc and Steel Stand 800 hours' Salt Spray

Increased use of zinc die castings and of zinc-plated steel to replace unavailable materials, combined with the tight supply of copper, nickel and chromium normally used for plating zinc, has focused attention on surface coatings comparable to plating in service performance. Unbiased laboratory tests show that at least two of the clear finishes in the company's line withstand the exceptionally long period of 800 hours' exposure to salt spray and to weatherometer tests.

Effectively protect zinc

These tests demonstrate that DULAC Clear Universal Lacquer #462 and CODUR Clear Synthetic Y743 provide completely satisfactory protection on zinc, zinc plated steel and steel. Even after the unusually severe tests to which these finishes were subjected, there was no indication whatever either of failure of the coating or of discoloration of the zinc.

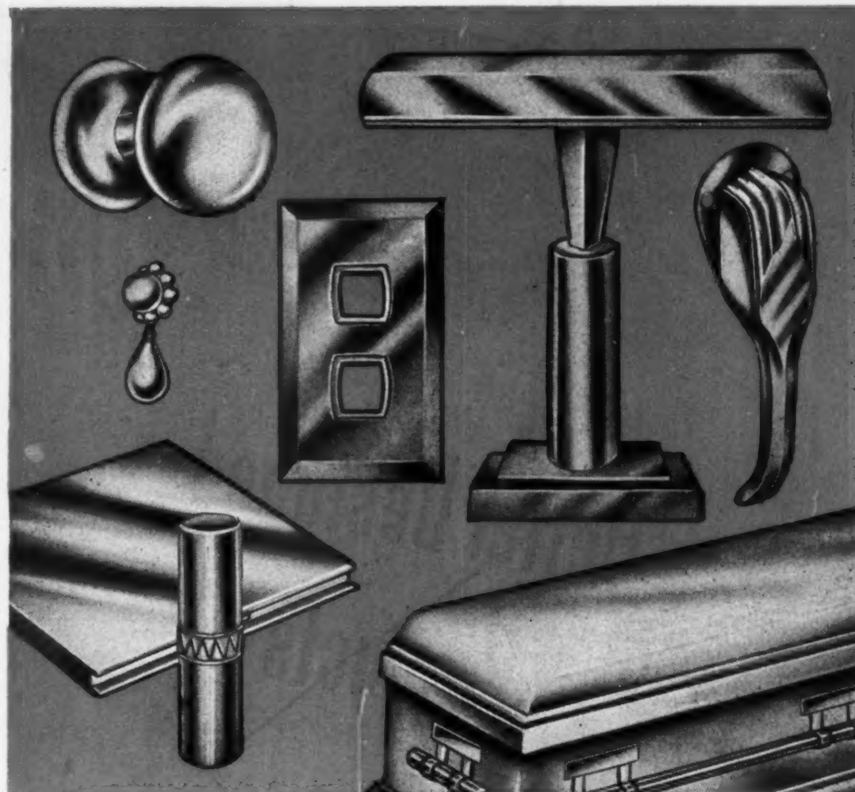


(Left) A zinc-plated steel panel newly coated with DULAC #462. (Right) A similar panel after 800 hours' exposure to salt spray, showing no evidence of attack on the finish.

Adaptability to Drying Schedules

While both finishes give the same performance, DULAC #462 is an air-drying coating, while CODUR Y743 is a baking type. This permits choice of the correct finish to fit into the drying schedules of a particular finishing room.

Technical Data Bulletin #110 on clear finishes is available from Maas & Waldstein Co., 430 Riverside Avenue, Newark 4, N. J. On request, M & W Technical Service Engineers will discuss specific problems.



NOW! simulate copper, brass and bronze on products like these with

M&W PLATELUSTRE

● Don't let critical metals put a *needless* crimp in your production!

Take zinc or steel—apply a coating of one of the new PLATELUSTRE finishes. You wind up with products and parts that look so much like copper, brass and bronze that *the eye can scarcely tell the difference!*

Whether you have been using now unavailable copper and its alloys for *making* products or for *plating* products, you will find these new M & W finishes *equally* effective in keeping your plant running. There are types for air-drying and baking schedules — pick the one that best fits *your* production requirements.

Let an M & W Technical Service Engineer show you—*right in your own plant*—how easy these PLATELUSTRE coatings are to use, and what striking effects they produce. Or, if you prefer, write for free literature.

PIONEERS IN PROTECTION

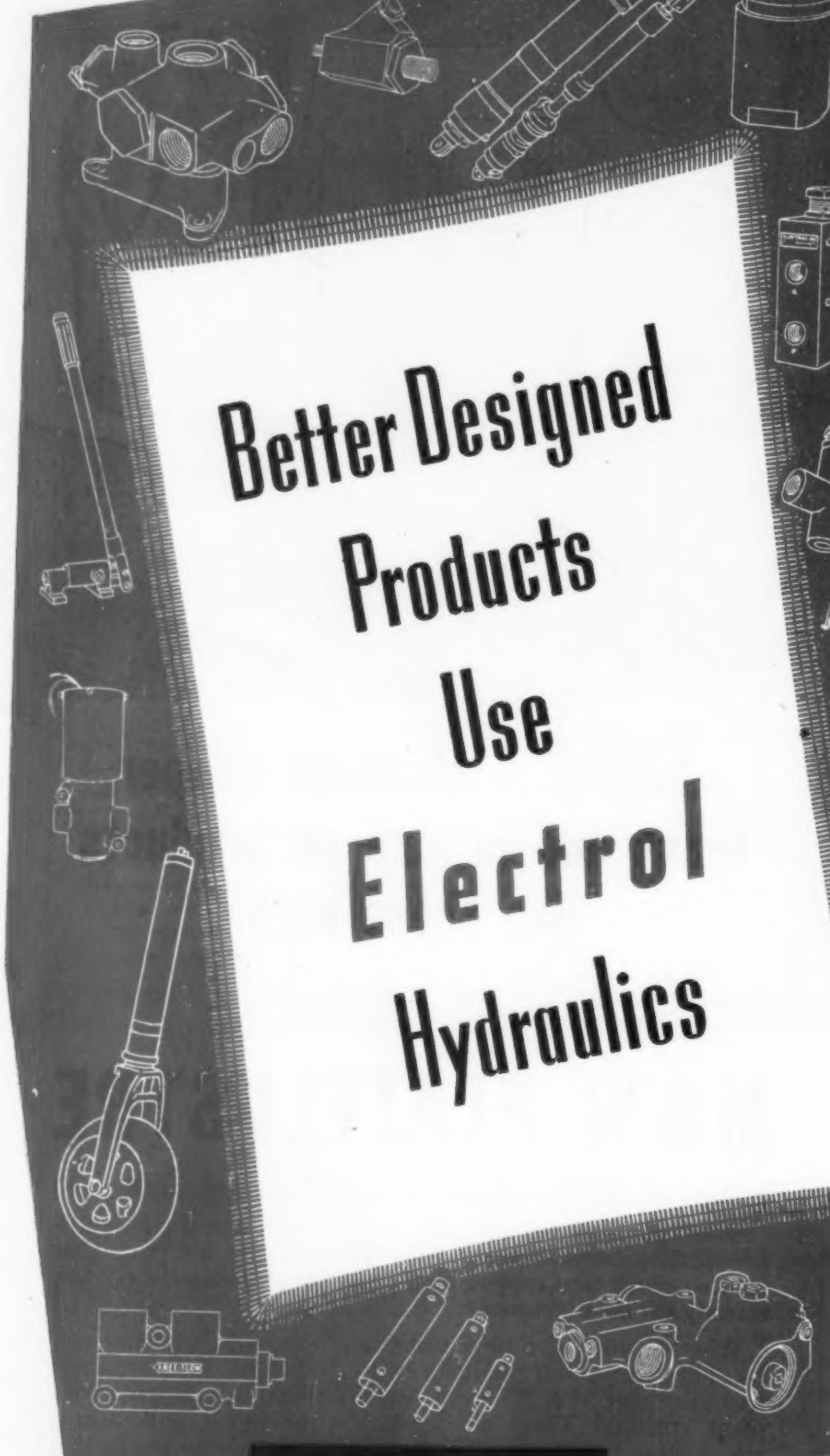
75th ANNIVERSARY M&W CO. 1876

MAAS & WALDSTEIN CO. 430 RIVERSIDE AVE. NEWARK 4, N. J.

MID-WEST DIV. - 1658 CARROLL AVE., CHICAGO 12, ILLINOIS

PACIFIC COAST DIV. - SMITH-DAVIS CO., 10751 VENICE BLVD., LOS ANGELES 34, CAL.

MANUFACTURERS OF INDUSTRIAL FINISHES



ing activities of the Austin-Western Co., another Baldwin-Lima-Hamilton subsidiary whose principal plant is at Aurora, Ill.

♦

The RCA Victor division of **Radio Corporation of America** recently announced that it plans to enter the home air-conditioning field. The first room air conditioners to be sold under the RCA Victor name and trademark will be placed on the market in January, 1952.

♦

A branch plant for the manufacture of electronic components has been opened in Kane, Pa., by the **Stackpole Carbon Co.,** St. Marys, Pa. The new plant contains approximately 45,000 sq ft of floor space.

♦

The H. O. Canfield Co., Bridgeport, Conn., has announced its entrance into the silicone fabricating field. Fabricator of rubber parts and accessories such as seals, gaskets and diaphragms, the company now offers the same service for contract work on silicone, with complete facilities for molding, extruding and die-cutting.

♦

By unanimous action of the board of directors, **Bridgeport Brass** Co. has decided to enter the aluminum business. This decision was based on a number of years of experimentation by Bridgeport engineering and production men.

♦

Copperweld Steel Co., Glassport, Pa., has purchased all the outstanding stock of Flexo Wire Co. Inc., Oswego, N. Y. With a capacity of approximately 500,000 pounds per month, Flexo Wire Co. will be operated as a wholly owned subsidiary of Copperweld. Facilities will be utilized for the immediate production of small and fine sizes of Copperweld wires and cables for the electronics and electrical appliance industries.

♦

The opening of an auxiliary plant to enlarge its manufacturing facilities in the Philadelphia area has been announced by **Conoflow** Corp. The company has arranged to lease a two-story building near the main office and factory.

♦

Kirkhill Rubber Co. has moved to a modern office and factory in Brea, Calif. The factory contains more than three acres on a 20-acre tract, with room for future expansion, some of which is already under way. New and larger mills, calenders, presses

and tubing machines have been included for increased production of standard or custom parts, molded rubber, lathe cut goods, extruded products, sponge rubber, sheeting and silicone products.

♦

Banner Manufacturing Co., manufacturer of welding equipment, recently moved into a new plant at 6820 North 43rd St., Milwaukee, Wis.

♦

Expansion of the Los Angeles plant of **Meletron Corp.** for the manufacture of pressure-actuated switches for industrial use has been announced. The building, located near the present factory, provides an additional 6000 sq ft of space.

♦

Automatic Steel Products Inc., Canton, O., has announced the acquisition of **Metroloy Corp.** of New Rochelle, N. Y. The latter company, a producer of cold-formed steel articles, is presently engaged in several research and development programs for the Armed Forces.

♦

A new addition to its No. 2 Chicago plant has been opened by **Bodine Electric Co., Chicago.** The new building has a floor space of 14,000 sq ft and will accommodate 100 employees of the motor winding department.

♦

Thermoid Co., Trenton, N. J, manufacturer of automotive and industrial rubber, has acquired stock control of the Essex Rubber Co., also of Trenton.

♦

The stock of **Hydraulic Equipment** Co., Cleveland, has been purchased by **The New York Air Brake Co.** The former company manufactures oil-hydraulic pumps, valves and cylinders used principally on earth moving and materials handling equipment.

♦

Meehanite Metal Corp., New Rochelle, N. Y., recently announced that the following companies have signed contracts for the production of Meehanite castings: **Compton Foundry,** Compton, Calif.; **Massey-Harris Co. Ltd.,** Toronto, Canada; **Bates & Co. Stoves Pty. Ltd.,** Melbourne, Victoria; **W. H. Dorman & Co. Ltd.,** London, England; and **A/B Kockums Mekaniska Verkstads,** Malmo, Sweden.

♦

Rezolin Inc., manufacturer of tool plastic for automotive, aircraft and industrial use, is building a 13,000-sq ft office and factory building at 5736 96th St., Los Angeles. Present Rezolin headquarters are at 4825 West Jefferson Blvd.

Society
ACTIVITIES

HERBERT HOOVER was awarded the Howard Coonley Medal for services to the voluntary standards movement at the annual meeting luncheon of the **American Standards Association** held in New York. He was cited for his work in national standardization projects when he was Secretary of Commerce in the 1920's, and for the importance he placed on administrative standards in the Hoover Commission Report for government reorganization issued in 1949.

♦

The headquarter offices of both the **Power Transmission Council** and the **American Leather Belting Association,** which were formerly located at 41 Park Row, New York 38, N. Y., have been moved to 320 Broadway, New York 7, N. Y.

♦

Edwin L. Marshall of New York University, New York City, and Stan Spaulding, Purdue University, Lafayette, Ind., have been selected by the **American Welding Society** as winners of the $200 first prize and the $150 second prize, respectively, in the 1951 A. F. Davis Undergraduate Welding Award.

♦

At its sixth annual instrument conference and exhibit, the following national officers were elected by the **Instrument Society of America:** Dr. Arnold O. Beckman, president; David M. Boyd Jr., vice president; Robert T. Sheen, vice president. Those still holding the offices of first vice president, vice president, treasurer, and secretary are, respectively, W. A. Wildhack, N. L. Isenhour, G. R. Feeley, and Richard Rimbach.

♦

Newly elected as president of the **American Standards Association** is Roger E. Gay, president of The Bristol Brass Corp. Edward T. Gushee, Detroit Edison Co., was elected vice president of the association. The new directors are: Willard Chevalier, McGraw-Hill Publishing Co., member-at-large, and R. D. Bonney, Congoleum-Nairn, Inc., representing the American Society for Testing Materials. Re-elected direc-

This machine practically thinks for itself!

Precision-boring a large fixture —an example of the accuracy and capacity of the Model 4-B DeVlieg JIGMIL.

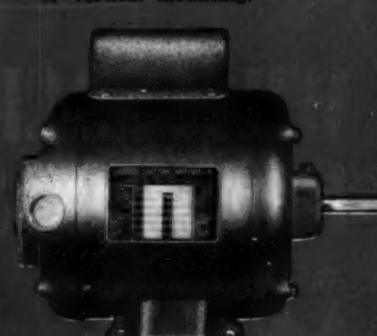
It's uncanny the way this DeVlieg JIGMIL handles the most complex boring and milling operations *automatically,* simply by pushing a button on the control panel.

For example — by simple push button control, the workpiece is positioned both horizontally and vertically, and holes are automatically spaced and bored to exact tolerances. A unique index table allows machining of parts from four sides without rechucking. A power tool lock permits locking or releasing cutting tools in a few seconds.

Howell engineers worked closely with this manufacturer to make sure each of the five Howell motors fitted its job exactly. The three 2-speed and two single-speed Howell motors make a vital contribution to the remarkable efficiency of this machine.

Howell will supply the same high degree of engineering skill and experience to your problems. You are assured of quality motors designed for your specific requirements, built to stand up under the heaviest production loads. May we handle your electric motor needs?

HOWELL Type K Motor. Totally enclosed, fan-cooled. Sealed against dust, dirt, fumes and moisture. Sizes from 3 to 150 H.P. at 1800 RPM. For horizontal or vertical mounting.



FRACTIONAL horsepower Howell motors, both single and polyphase, are usually carried in stock. Furnished in standard NEMA frames as either open or totally enclosed types.

HOWELL Red Band MOTORS ®

HOWELL MOTORS

HOWELL ELECTRIC MOTORS CO., HOWELL, MICH.

Precision-built industrial motors since 1915

tors are: Hoyt P. Steele, Benjamin Electric Manufacturing Co., representing the National Electrical Manufacturers Association; R. A. Colgan Jr., Shasta Forests Co., representing the National Lumber Manufacturers Association; Miss Ardenia Chapman, Drexel Institute of Technology, formerly a director-at-large, now representing the American Home Economics Association.

The Gray Iron Founders' Society's Gold Medal award, the association's highest honor, was presented to Walter L. Seelbach, president, Superior Foundry Inc., at the Society's 23rd Annual Meeting in Chicago. Mr. Seelbach was cited for the award by reason of his sincere devotion to the formation, welfare and progress of the Society. He served as its first president in the years 1928-1930, again in 1943-1945, as treasurer in 1935-1937, and as a member of the Board of Directors for 13 years.

New officers of the **Gas Appliance Manufacturers Association** were installed at a special meeting of the board of directors in St. Louis, October 14. They are: Louis Ruthenburg, president; A. B. Ritzenthaler, first vice president; J. F. Donnelly, second vice president; Lyle C. Harvey will retain his position as treasurer while H. Leigh Whitelaw will remain as managing director and secretary.

The American Society for Metals has set aside a total of $6000 annually to be given as awards to teachers of metallurgy in any school in the United States or Canada. Three awards of $2000 each will go to those teachers of metallurgy whose performance and influence upon the general progress of the profession are judged best. Judging of the candidates' applications and particulars for the awards will be carried out by a special committee appointed by the board of trustees of the ASM.

CORRECTION: In the October issue of MACHINE DESIGN, the officers of **The National Association of Aluminum Distributors** were incorrectly listed. The correct roster is as follows: President, H. L. Edgcomb Jr., Edgcomb Steel Corp.; vice president, T. S. White, Nottingham Steel Co.; vice president, W. W. Doxey, T. E. Conklin Brass & Copper Co. Inc.; treasurer, R. W. Shaw Jr., A. R. Purdy Co.; and secretary, R. L. Collier, Cleveland, O.

The 3 of Us Make a Great Team!

SALES AND SERVICE

Personnel

CHANGES in the glues and industrial resins sales organization of the Plaskon division, Libbey-Owens-Ford Glass Co. were announced recently. **H. A. Raymond Jr.** has been made sales manager for industrial resins and will supervise national sales of Plaskon urea and phenolic glues, aminoplast paper-treating resins, etc. **Ralph W. Burdeshaw** was appointed to the new post of southern sales manager for industrial resins and will direct sales activities in the middle Atlantic, south-eastern and south central states. **Robert D. Weant** has joined the division as sales representative in the states of South Carolina, Georgia, Florida and Alabama, the territory formerly handled by Mr. Burdeshaw. **W. W. Wommack** has joined the molding compound sales force of the division, and **Donald Delaney** has been appointed sales manager and **Victor W. Ginsler**, assistant sales manager, for coating resins.

♦

A. J. Shradel has been named manager of the Seattle district sales office of Cutler-Hammer Inc., Milwaukee. He succeeds **T. N. Bristow**, who is retiring after 23 years of service with the company. In his new position Mr. Shradel will also supervise the Portland, Ore., office in the sale of motor control and allied electrical apparatus.

♦

Charles H. Besly and Co. of Chicago and Beloit, Wis., has appointed **J. W. Oliver** as district manager for eastern Michigan, Indiana, western Ohio and Kentucky.

♦

General Electric Co. recently announced a number of new appointments in several departments. Formerly manager of engineering of the large apparatus division, **Francis K. McCune** has been appointed assistant manager of the engineering services division. **K. Jerry Morray** of the Chemical division has been transferred to the company's silicone plant at Waterford, N. Y., as a headquarters' sales specialist. **Carl H. Rinne** has been named general manager of the specialty transformer and ballast department at Fort Wayne, Ind., succeeding **William C. Wichman**, now

general manager of the component products division. **C. Howard Black** is now general manager of the meter and instrument department at Lynn, Mass., and **William L. Rodich** has been promoted to assistant general manager of the laminated and insulating products department of the chemical division.

♦

John M. Dumser has been appointed assistant to the general sales manager of the Wolverine Tube division of Calumet and Hecla Consolidated Copper Co., Detroit.

♦

Appointment of **Archie K. Beard** as Midwest sales manager has been announced by Turco Products Inc., Los Angeles. At the same time, **Harold P. Galvin** was named to the post of general manager of the company's Midwest division factory with headquarters in Rockdale, Ill.

♦

Arthur H. Sy, formerly sales manager, has been named vice president in charge of sales for American District Steam Co. Inc., North Tonawanda, N. Y. Mr. Sy has been with the company since 1923, serving in various capacities in production, engineering and sales. He will now have complete responsibility for main office sales functions, as well as supervision of district sales offices in Buffalo, Chicago, New York, Philadelphia and Pittsburgh.

♦

Appointed southern territory district manager, **H. Gilbert Stewart** will represent Atlas Chain and Manufacturing Co. in Florida, North and South Carolina, Tennessee, Mississippi, Georgia and Alabama.

♦

C. E. Thomas has joined the sales staff of Chiksan Co., Brea, Calif., and has been assigned to the company's eastern headquarters in Newark, N. J.

♦

In line with its program of expansion in the aircraft accessory field, the National Water Lift Co., Kalamazoo, Mich., has appointed **C. E. Willis** as sales manager. Prior to his new appointment, Mr. Willis was associated with Lear Inc. as chief engineer and, for several years, assistant sales manager.

♦

A. Milne & Co., New York, solid and hollow tool steel distributor, recently announced two new appointments. **Courtland W. Schefer** has been named manager of the company's Philadelphia office and ware-

house, and **Edward J. Silk** has been appointed Connecticut sales representative with headquarters at the New Britain office and warehouse.

♦

D. V. Perry has been named to the position of assistant sales manager of the spray painting and finishing division of DeVilbiss Co., Toledo, O. Succeeding Mr. Perry as eastern district manager is **C. B. Gracely,** who formerly was manager of the company's office at Houston, Tex. Mr. Perry's office will be at the main plant in Toledo, and Mr. Gracely will be located at the Newark, N. J., branch.

♦

Making his new headquarters in Oswego, N. Y., **T. Y. Henry** has been appointed division manager of the new Copperweld Steel Co. subsidiary, Flexo Wire Co. Mr. Henry's broad experience in the wire industry includes work in designing, testing and acting as a consultant for electronic applications.

♦

Major changes in the industrial sales organization of the conveyor division of The Jeffrey Manufacturing Co., Columbus, O., were announced recently. **Lincoln Kilbourne,** formerly manager of sales of the products engineering division, was named manager of sales for the conveyor division. **Dan Knies** and **A. W. Lemmon** have been named consultant sales engineers of the conveyor division.

♦

Paul E. Wilson, 2636 South Michigan Ave., Chicago 16, Ill., has been appointed exclusive representative in the Chicago and northern Illinois territory for the Hydro-Line Manufacturing Co. line of air and hydraulic cylinders.

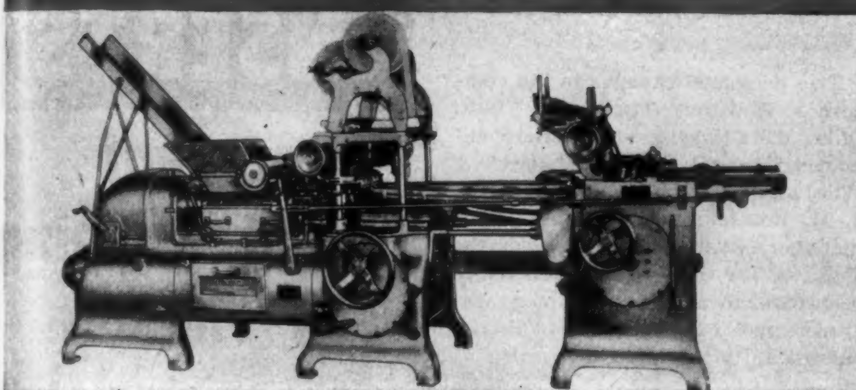
♦

J. W. Spoor has been named general sales manager of the welding products division of A. O. Smith Corp., Milwaukee.

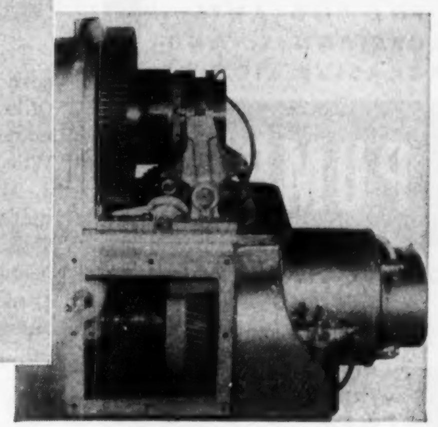
♦

Brenholts, Goin & Ogg Inc., 201 East Carson St., Pittsburgh 19, Pa., was incorporated recently as a management consulting organization to aid and assist business enterprises toward the accomplishment of their objectives in the fields of production, industrial engineering, industrial relations, advertising and sales. **Howard F. Brenholts,** Pittsburgh industrialist, is president of the new corporation. **Newbold C. Goin,** vice president, for the past ten years served as executive secretary of the American Gear Manufacturers Association. Prior to that

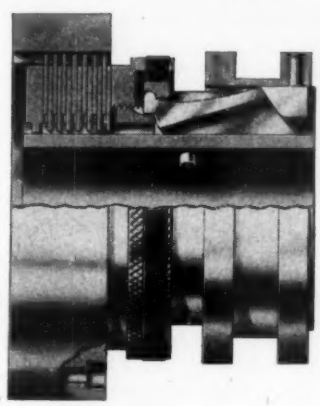
MAXITORQ keeps good company



THE MACHINE



THE INSTALLATION



THE CLUTCH

For six years the Lynch Corporation, Packaging Machine Division, Toledo, Ohio, has used two Maxitorq floating disc Clutches in this Morpac butter print forming, wrapping and cartoning machine.

Their chief engineer says, "The larger (No. 28) clutch drives a pair of intermittent worms which fill the mold with the product. The clutch starts and stops the worms 75 times per minute. Even at this speed we maintain product variation of only 1/16 of an ounce per pound. We have found it to be dependable and efficient." The No. 25 clutch transmits power for machine operation.

Maxitorq clutches in 8 sizes from ¼ to 15 H.P. @ 100 r.p.m.... single or double, wet or dry... are used as original equipment in a great variety of nationally known machines and products. There are no finer or more dependable clutches made... and they keep good company with good companies. Investigate them!

Send for Bulletin No. MD 12

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

time he was an executive in the sales organization of Westinghouse Electric Corp. **Erson V. Ogg,** vice president, recently left his staff position as director of industrial engineering with the Chase Brass & Copper Co.

♦

Two personnel changes in the company's Houston, Tex., and Tulsa, Okla., district sales offices were announced recently by The Babcock & Wilcox Tube Co. of Beaver Falls, Pa. **J. H. Roach,** named assistant sales manager, was transferred from the Tulsa office to Houston, and **W. C. Mohrman,** formerly at Houston, was transferred to Tulsa as a district salesman.

♦

William H. Sisson has been named power industry manager of Minneapolis-Honeywell Regulator Co. He will make his headquarters at Philadelphia.

♦

Two sales engineers with Cummins Engine Co. Inc., Columbus, Ind., have been transferred from the factory to regional liaison offices as assistant regional managers. **R. A. D'Amour** has been assigned to the Washington, D. C., region, and **G. W. Plondke,** to the central region, with offices in Chicago.

♦

The appointment of **John A. Rozos** as director of exports has been announced by Dodge Manufacturing Corp., Mishawaka, Ind.

♦

With offices at New Orleans, **Julius H. Nill** has been appointed southern regional manager of Metallizing Engineering Co. Inc., Long Island City, N. Y. Associated with the firm since 1945, Mr. Nill served as field engineer for the middle and southern Atlantic states prior to his new appointment.

♦

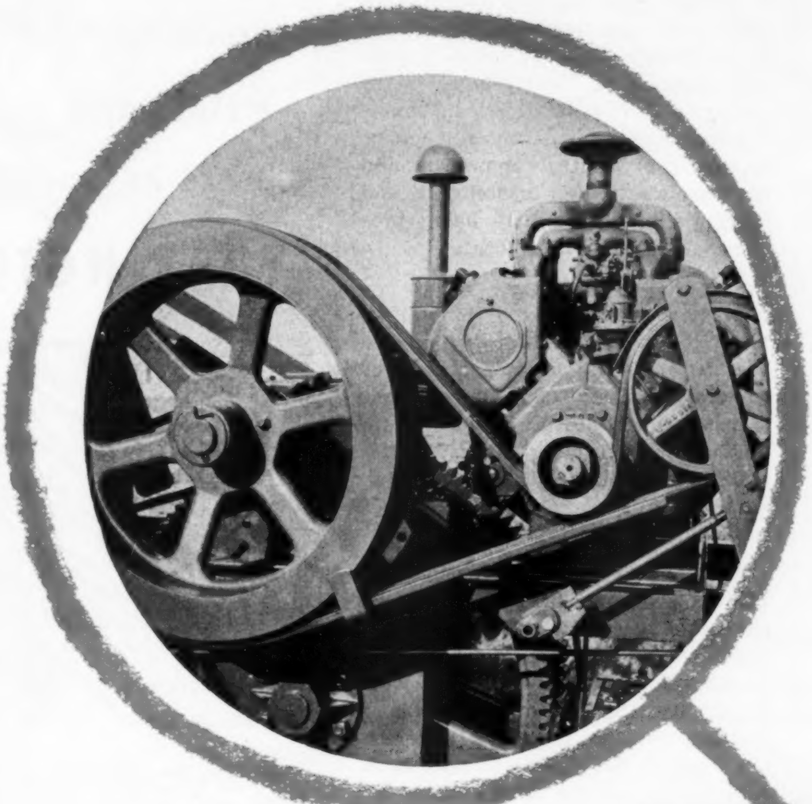
Raymond H. Fara has been appointed manager of the branch office of Belgian Electric Sales Corp. which was recently opened in the Leader Bldg., Cleveland. Mr. Fara was previously connected with the East Coast branch office of the corporation.

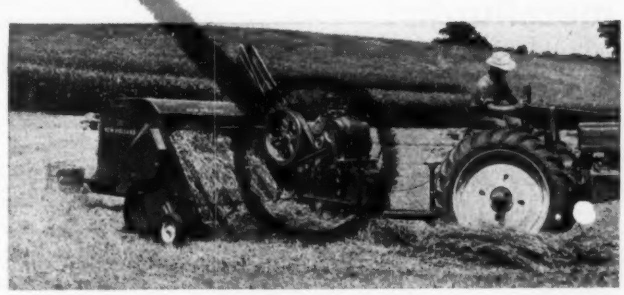
♦

To succeed **L. C. Barton,** who has retired, **W. H. Prewitt Jr.** has been appointed manager of the Atlanta, Ga., branch office of the electrical division of Wagner Electric Corp., St. Louis. Mr. Prewitt joined the company as a student engineer in

NEW HOLLAND Hay Baler and GILMER Multiple V-Belts

TEAMED FOR TOP PERFORMANCE!





Baling is a one-man job with the New Holland Machine Company's Model 77 twine-tying automatic baler. Gilmer Multiple V-Belts contribute to its top performance.

Here's a noteworthy example of a machine designer's ingenuity ... and Gilmer V-Belts' versatility. The main drive on the New Holland Model 77 twine-tying hay baler is unusual in that it employs Gilmer V-Belts *running up-side-down!*

The multiple V-Belts drive off the small diameter sheave, while the *backs* of the belts operate over the large flywheel and the idler pulley. Ingenious designing!

Equally shrewd was the choice of GILMER V-Belts—engineered and built to take abnormal usage in their stride! It is unusual for V-Belts to be called upon to stretch and compress alternately on *both top and bottom.* But this two-way stretch puts little added strain on GILMER V-Belts. Their bias-woven jackets permit flexing in either direction. And their load-carrying, high-tensile-strength cords are centrally located—occupying the entire pitch-line area of the belt. All components are thoroughly bonded, so flexing in either direction creates a minimum of internal friction.

For greatest flexibility in designing, plan your drives around Gilmer's broad range of sizes . . . and give users the convenience of prompt replacement service through Gilmer's nation-wide distributor network. If special belts are required—or if you'd like assistance with your drive problems, Gilmer engineers and Gilmer production facilities are at your service.

L. H. GILMER COMPANY

1203 Tacony, Philadelphia 35, Pa.

Division of United States Rubber Company

Gilmer BELTS

1935, went to the Cincinnati branch as a salesman the following year, and was transferred to Atlanta early this year.

◆

Manager of the control section of Allis-Chalmers Mfg. Co. since 1946, **F. C. Ludington** has been named manager of the company's Hawley Works in West Allis, Wis. In his new post, Mr. Ludington will have direct authority and responsibility in directing the sales, engineering and manufacturing of control apparatus and the manufacture of switchgear and other products currently being produced in the Hawley Works.

◆

In view of rapid expansion of defense production in industry on the West Coast, Carboloy department of General Electric Co., Detroit, has transferred **Arthur E. Johnson** from its customer training school in Detroit to the Pacific district office in Huntington Park, Calif.

◆

As a result of the retirement of **Park Q. Wray,** vice president in charge of sales, **L. C. Cole** has been appointed director of sales for National Motor Bearing Co. Inc., Redwood City, Calif. Formerly head of National Motor Bearing's advertising agency, Mr. Cole will now have full charge of the firm's sales organization. He will also have functional responsibility for sales of Arrowhead Rubber Co. at Downey and Long Beach, Calif.

◆

E. H. Stau has been named sales manager of the newly created Pacific division of Townsend Co., effective January 1, 1952. Formerly general manager of Cherry Rivet Co., a division of Townsend Co., Mr. Stau will direct sales activities for the parent company on all cold-headed metal products in the Pacific Coast states. In addition, he will direct aircraft and government contacts for the Cherry Rivet line of specialized fasteners on a national basis.

◆

Lincoln Engineering Co., St. Louis manufacturer of equipment for the application of lubricants, has elected **L. L. Meikle** as president of the Lincoln Engineering Co. of California. He will actively supervise the entire West Coast division, comprising the states of Arizona, California, Nevada, Oregon, Washington and western Idaho. Mr. Meikle succeeds **C. Homer Redd,** who will continue his association with the company in an advisory capacity.

SALES

Notes

GROUND was broken recently for a new sales and service building to be erected by **Veeder-Root Inc.**, Hartford, Conn. To serve the southern and southeastern territory, the building is located on Route 29 between Greenville, S. C., and Spartanburg. When completed it will replace the company's present offices at 231 West Washington St., Greenville.

•

E. W. Bliss Co., Canton, O., has announced the appointment of the **Iowa Machinery and Supply Co.**, Des Moines, Iowa, as sales representative for the central portion of Iowa. Repair and service functions for all Bliss machinery will also be handled.

•

The Plaskon division of **Libbey-Owens-Ford Glass Co.**, Toledo, O., has established a New England office for glues and industrial resins to be located at No. 10 High St., Boston, Mass. This office will cover new and expanded sales territories in New England, New York and eastern Pennsylvania.

•

Kenny Consolidated Engineering Industries Ltd., 58 Wellington St. E., Toronto, Canada, has been named Ontario representative for the **Warner Electric Brake & Clutch Co.** of Beloit, Wis.

•

Chicago Steel Service Co. recently opened its new general offices and warehouse located on Kildare Ave. at 45th St., Chicago. New service facilities include five heavy-duty overhead cranes, a battery of shears, automatic hack-saw equipment, high-speed friction saw and a four-torch plate burner with an electronic tracing device.

•

To provide better service to customers in the Cleveland area, the Cellulose Products department of **Hercules Powder Co.** has established an independent branch sales office in the Union Commerce Bldg., Cleveland 14, O.

•

Builders Iron Foundry of Providence, R. I., recently presented a five-day course in "Foundry Practice and Casting Design" to design engineers, draftsmen, production engineers, supervisors, inspectors and purchasing

agents. In addition to a number of technical personnel of Builders Iron Foundry, the teaching staff consisted of representatives from nine other companies, including the **Meehanite Corp., General Electric Co., Air Reduction Sales Corp.,** and others. Thirty-nine hourly lectures were given on eight different phases of the subject.

♦

Ace Abrasive Laboratories, New York, manufacturer of diamond powders and compounds, has expanded its engineering service department to accommodate an increasing number of requests for information on the correct use of abrasive materials.

♦

For the second year, **Republic Steel Corp.** is making available without charge the services of ten speakers to address civic, fraternal, women's, church and school clubs and organizations in the greater Cleveland area. The reports on business by Republic executives include such topics as a behind-the-scenes look at the company's $75,000 steel expansion in Cleveland, a report on production and prices and a color-slide illustrated presentation of iron-ore mining and shipping on the Great Lakes.

♦

The Chicago district office of **The Emerson Electric Mfg. Co.** recently moved to larger quarters at 1623-25 South Pulaski Rd., Chicago 23, Ill. All warehouse and office operations are consolidated in the new quarters.

♦

A new factory branch store has been opened by **Link-Belt Co.** at 108 South Fourth West St., Salt Lake City 1, Utah.

♦

The western division sales office of the **Wheelco Instruments Co.,** manufacturer of industrial measuring, controlling and recording instruments, has been moved to larger offices at 2320 Milwaukee Ave., Chicago. In addition to being a clearing house for branch office sales activities, the new office will also provide complete sales and service facilities for Chicago and fringe areas of Illinois, Indiana and Iowa.

♦

Announcement was made recently by **Minnesota Mining & Manufacturing Co.,** St. Paul, of the formation of a wholly-owned subsidiary to develop and handle foreign interests of the company. The new subsidiary will be known as **Minnesota Mining & Manufacturing International Co.**

Guarding Signal Corps Equipment from Fastener Failure

Communications equipment for mobile tactical units must be sturdy enough to follow the front lines cross-country and along battle-pitted roads. This AN/GRC-3 radio equipment, installed in all types of combat vehicles, must be ready to provide communications liaison between advancing units. And it must be ready twenty-four hours a day, despite the roughest operating conditions. For vital equipment of this type there is a growing recognition of the need for self-locking fasteners to protect the expensive and critical component parts which make them function.

Helping to keep this equipment operating by holding against severe and long-continued vibration are many ESNA machine screw hex nuts and clinch nuts. These Elastic Stop Nuts—*with fungus proof nylon inserts for extended reuseability*—offer the advantages of secure fastenings and at the same time simplify maintenance and field repairs.

ESNA HEX NUTS are quickly installed with power tools—permit accurate, precise adjustments, lock at any position along the bolt, and keep fastenings tight until deliberately removed.

ESNA CLINCH TYPE NUTS are available in various shank lengths for swaging on different gauges of sheet metal. Permanently clinched into place on frame members or to sections of the chassis, they provide permanent and pre-positioned fasteners for assembling panels or mounting component parts.

Red Nylon locking inserts Reusable over 100 times

DESIGN AHEAD WITH ESNA

THE FAMOUS RED ELASTIC COLLAR IS VISIBLE EVIDENCE OF LOCKING SECURITY

Threadless and permanently elastic, it provides these 4 outstanding features:

1. **Protects against nuts loosening due to VIBRATION**
2. **Keeps locking threads CORROSION FREE**
3. **Provides for accurate BOLT LOADING**
4. **Seals against LIQUID LEAKAGE along the bolt threads**

And can be used again and again

Specify ESNA hex and clinch nuts with the new red nylon insert *to assure adequate locking torque through hundreds of on-off applications.*

When you design equipment that needs similar fastening security, specify Elastic Stop Nuts. For complete dimensional and installation data write to Elastic Stop Nut Corporation of America, Vauxhall Road, Union, N. J.

ESNAIL ® ESNA TRADE MARK ROLLPIN TRADEMARK

ELASTIC STOP NUTS

DESIGN HEADQUARTERS FOR VIBRATION-PROOF FASTENERS

Meetings

AND EXPOSITIONS

Dec. 17-19—
American Society of Agricultural Engineers. Winter meeting to be held at the Stevens Hotel, Chicago, Ill. Raymond Olney, P. O. Box 229, St. Joseph, Mich., is secretary.

Jan. 14-17—
Plant Maintenance Conference. Third conference to be held concurrently with the Plant Maintenance Show at Convention Hall, Philadelphia, Pa. Additional information may be obtained from the exposition management, Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 14-18—
Society of Automotive Engineers. Annual meeting to be held at Hotel Book-Cadillac, Detroit, Mich. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Jan. 16-18—
Society of Plastics Engineers. Eighth annual national technical conference sponsored by the Chicago section of the SPE to be held at the Edgewater Beach Hotel, Chicago, Ill. Mrs. Bess R. Day, 409 Security Bank Bldg., Athens, O., is executive secretary.

Jan. 18—
Malleable Founders' Society. Semi-annual meeting to be held at Hotel Cleveland, Cleveland, O. Additional information may be obtained from society headquarters, 1800 Union Commerce Bldg., Cleveland, O.

Jan. 28-Feb. 1—
Institute of the Aeronautical Sciences. Twentieth annual meeting to be held at the Astor Hotel, New York, N. Y. R. R. Dexter, 2 East 64th St., New York 21, N. Y., is secretary.

Mar. 3-7—
American Society for Testing Materials. Spring meeting to be held at the Statler Hotel, Cleveland, O. Additional information may be obtained from society headquarters, 1916 Race St., Philadelphia 3, Pa.

Mar. 4-6—
Society of Automotive Engineers.

Passenger car, body and materials meeting to be held at the Book-Cadillac Hotel, Detroit, Mich. John A. C. Warner, 29 West 39th St., New York 18, N. Y., is secretary and general manager.

Mar. 7—

Malleable Founders' Society. Eastern sectional meeting to be held at the Commodore Hotel, New York, N. Y. Additional information may be obtained from society headquarters, 1800 Union Commerce Bldg., Cleveland, O.

Mar. 11-14—

Society of the Plastics Industry. Fifth national plastics exposition to be held at Convention Hall, Philadelphia, Pa. William T. Cruse, 67 West 44th St., New York 18, N. Y., is executive vice president.

Mar. 17—

American Society of Tool Engineers. Twentieth annual meeting and industrial exposition to be held at the International Amphitheatre in Chicago, Ill. Harry E. Conrad, 10700 Puritan Ave., Detroit 26, Mich., is executive secretary.

Mar. 17-19—

Midwestern Conference on Fluid Mechanics. Second conference to be held at Ohio State University, Columbus, O. Additional information may be obtained from Professor Geoffrey Keller, conference secretary.

Mar. 18-19—

Steel Founders' Society. Annual meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 920 Midland Bldg., Cleveland, O.

Mar. 22-Apr. 6—

International Trade Fair. Second trade fair to be held at the Navy Pier in Chicago, Ill. John N. Gage, Colonel, U. S. A. (Ret.) 10316 Merchandise Mart, Chicago 54, Ill., is executive vice president.

Mar. 24-26—

American Society of Mechanical Engineers. Spring meeting to be held at the University of Washington, Seattle, Wash. C. E. Davies, 29 West 39th St., New York, N. Y., is secretary.

New Machines

Communication Equipment

INTERCOMMUNICATIONS SYSTEM: For use in industrial installations, offices, stores, factories and institutions. Incoming calls may be answered from a distance of up to 40 ft from any master station or substation; master stations may talk with each other; substations may be called selectively, or exclusively by any master station; any master may be used privately or nonprivately. Designed for systems requiring more than one master station along with substations. Model CL-5 is a combination system for five station use; CL-10 is for ten stations. Master stations equipped with talk-listen switches, stand-by, station selectors, volume control; staff stations require no manual operation. *Talk-A-Phone Co., Chicago, Ill.*

Domestic Equipment

DOUBLE-OVEN RANGE: Large master oven and smaller companion oven are equipped with 3000-watt bake unit and 4000-watt broil unit. Master oven can be operated by automatic timer, which also times one of the appliance outlets on control panel. Has two 8-in. surface units, one 6-in. utility unit and one extra high-speed 6-in. unit, all operated by push-button controls mounted at top of control panel behind work surface. Has two storage drawers with a total of more than 2½-cu ft capacity. *General Electric Co., Bridgeport, Conn.*

EDGER: Rowel-Ezy trims grass along sidewalks, around flower beds or against fences and trees. Rubber-tired driving wheel propels self-sharpening blades at any angle from either sod or concrete. *Rowe Tool Co., Glendale, Calif.*

WASHING MACHINE: Fully automatic unit washes, double rinses, spin-dries and shuts itself off. Push-pull switch stops or starts washer at any point in cycle. Once stopped, machine can be restarted at exact moment of cycle interruption or can be made to repeat or skip any stage of cycle. Small-load selector permits washing of up to five lb of laundry using 10 gal of water in each cycle. At capacity, tub holds 17 gal of water and up to nine lb

of dry clothes. Lid portion of cover lifts off for use as laundry tray; entire cover assembly is quickly removable for cleaning of tub. Features white porcelain tub and interior light. *General Electric Co., Bridgeport, Conn.*

Heating and Ventilating

AIR FILTER: Operates at face velocities of 300 to 500 feet per minute with minimum resistance. Viscous type filter core is constructed of horizontal layers of galvanized wire mesh arranged to assure a large filter area with little pressure drop. The construction is such that air flows into divided channels, being baffled by a filter wall. *Air Filter Corp., Milwaukee, Wis.*

AIR CONDITIONER: Self-contained 7½-ton capacity unit for average size retail stores or offices. Delivers 2700 cfm of conditioned air; has air throw of 75 ft. Complete mechanism located within cabinet; controls located behind small access panel on the front of the cabinet, automatic or manual controls. Comprised of compressor section at bottom, cooling coil or air intake section, and air discharge section, the unit is adaptable for conditioning air for several rooms. Outside air can be brought into unit. Two-row steam heat coil available. Size: 28 by 40 by 86⅜ in. *Frigidaire Division, General Motors Corp., Dayton, O.*

Manufacturing Equipment

PORTABLE AIR DRILLS: Available in several speeds, ¼-in. capacity. Feature one-piece housing, redesigned five-vane air motor, built-in automatic lubricator, muffler to minimize exhaust noise, exhaust deflector, palm-fitting handles. Attachments available to adapt tools to reaming, tapping, wire brushing, sanding, screw-driving, nut-running and close quarter drilling. Weights range from 2⅜ to 3⅛ lb. *Ingersoll-Rand Co., New York, N. Y.*

BAND SAW: For metal, plastic, sheet metal and wood. Chain drive eliminates blade chatter and delivers full power at slow speeds. Speed range from 125 to 2200 fpm. Takes blade up to ½-in. wide. Saws stacked galvanized sheet metal at speeds up to 15 in. per minute. Table size, 20 by 22 in.; overall depth, 34 in.; overall height, 34 in. Set of four clamps and riser bar insert to match included for sheet metal work. *Bett-Marr Mfg. Co., Hopkins, Minn.*

ARC WELDER: Portable unit with welding range of 20 to 80 amps; handles $\frac{1}{16}$ to ⅛-in. rods on work rang-

ing from 24 gage to ¼-in. sheet metal. Has nine heat stages adaptable to either arc welding process or twin carbon torch method. Operates from 110-v a-c line. *Trindl Products Ltd., Chicago, Ill.*

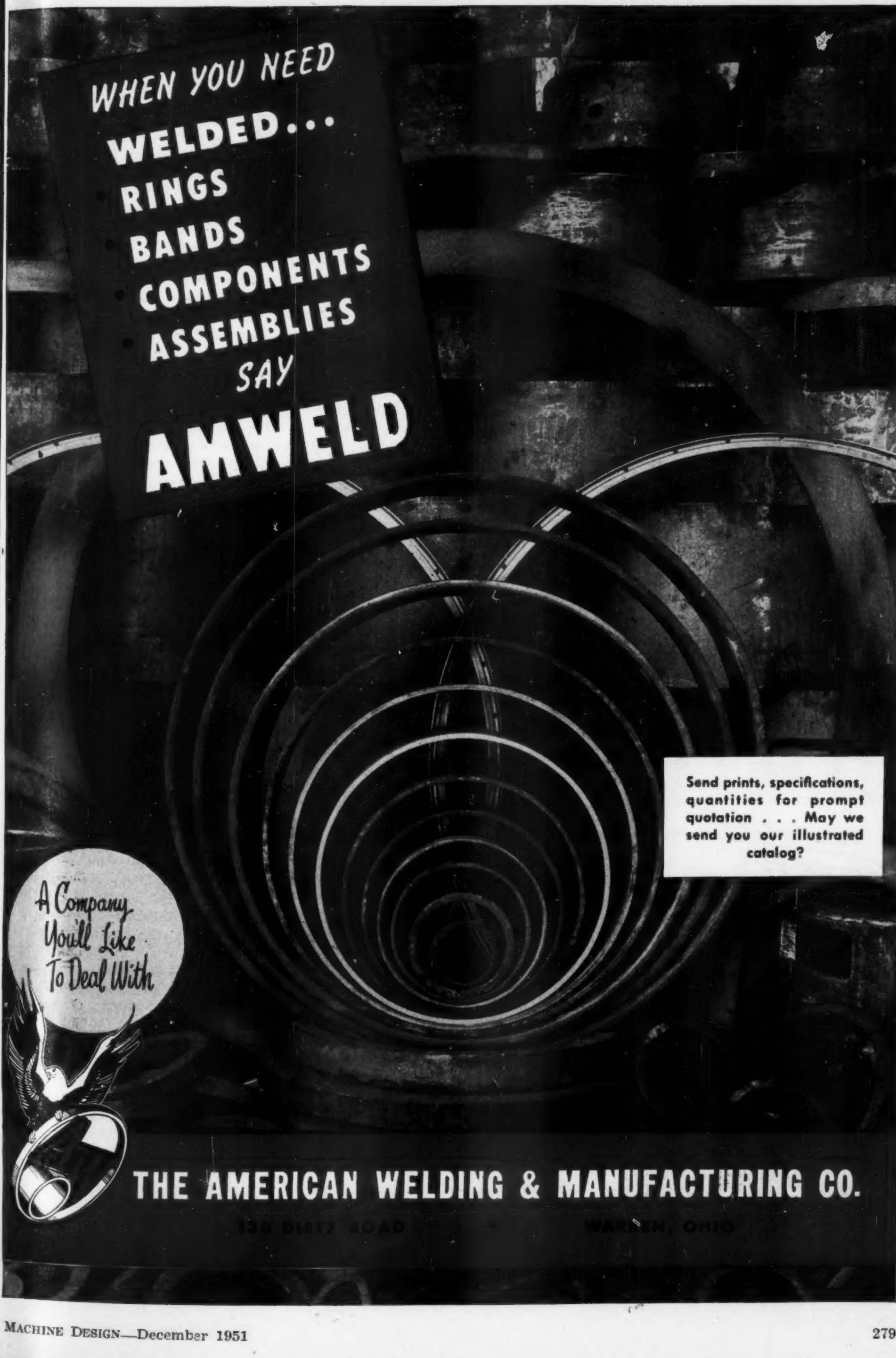
AIR PRESSES: Twenty models available in ½ to 3½-ton capacity. Feature frictionless cylinder of diaphragm design requiring no lubrication. Have built-in pressure gages, infinitely adjustable stroke coupled with extra long maximum strokes. Ram keyed to prevent rotation, large working surface, infinite adjustment vertically with no bolts to loosen or remove. *Famco Machine Co., Racine, Wis.*

AIR-HYDRAULIC DRILL: For high production work on drilling, reaming, tapping, chamfering, spot-facing, centering, etc. Designed as basic unit adaptable to special machines for high production drilling, etc. Feed control infinitely variable from 0 to 70 in. per minute. Rapid advance of 6 in. per sec. is variable in length up to full stroke of unit. Total stroke variable from 0 to 1½ in. by means of a positive stop. Return rate is 5 in. per sec. Takes up to 5/16-in. drill in steel, and a ⅓ or ½-hp motor. *Delta Power Tool Division, Rockwell Manufacturing Co., Milwaukee, Wis.*

METAL FORMING MACHINE: Developed primarily for short-run production work. Has capacity to bend 15 in. of 18-gage mild steel or equivalent. Forms sheet, strip and rod stock and small tubing into innumerable shapes. Forms any desired radius from 1/32 to ⅝-in.; makes boxes up to 15 by 15 by 5 in. Handles low-ductility materials and plated or painted metals without fracture or injury to surface where radius of bend is large enough to avoid cracking paint. Bends of any angle, including complete folds, can be made. *Kilham Engineering Inc., Plainville, Mass.*

WIRE STRIPPER: High-speed unit for production wire stripping. Circular cutting knives remove insulation from solid, stranded or multiconductor cable up to ½-in. diameter. Stripping length adjustable up to 1½ in. Has ¼-hp, 110-v direct connected motor. *High Speed Hammer Co. Inc., Rochester, N. Y.*

BAND TOOL MACHINE: Light duty unit for sawing, filing, polishing. Has 16 in. throat, 12 in. thickness capacity. Provides both high and low tool speed ranges without changing belts, pulleys or motors. Speed is infinitely variable by handwheel control and two-speed geared trans-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mission giving speed ranges from 50 to 300 fpm and from 860 to 5200 fpm. For conventional metal sawing, high-speed nonferrous sawing and light gage friction sawing. Includes saw band welder which enables making internal cutouts such as die openings. Takes standard saw bands up to ½-in. width; file bands ¼, ⅜ and ½-in. wide; and ¾-in. polishing bands. *The DoAll Co., Des Plaines, Ill.*

MOVABLE FRAME PRESS: For handling large, awkward parts. Has large area table on which work can be lowered by hoist or crane. Frame is then moved over table. Workhead movable from side to side along frame channel and up or down to adjust to height of work. Available in 25, 50, 75 and 125-ton capacities for either electric or air-powered hydraulic operation. *Dake Engine Co., Grand Haven, Mich.*

CONTINUOUS MILL: Adaptable to fine or coarse grinding, wet or dry grinding, open or closed circuit grinding. For pulverizing chemical raw materials, ceramic raw materials, minerals, and finished products. May be used to produce finished product, or may be operated in conjunction with various types of Patterson classifying equipment. Hollow trunnions provided for continuous feed and discharge of materials. Features cast-steel mill heads slightly conical in shape to provide rigidity and strength. Sizes of mill range from 2 by 2 ft to 10 by 24 ft. *Patterson Foundry & Machine Co., East Liverpool, O.*

Materials Handling

CLAMP ATTACHMENT: Designed to fit Spacemaster line of gasoline and electric fork trucks. Lifts, transports, stacks, and unpiles variety of materials. Handles boxes, cases or unit loads up to 1700 lb, 48 in. long on pallets, bins or skid platforms when lifting arms are used as conventional forks. When hydraulic side clamping feature is used, clamp handles rolls or bales singly or several at a time, compressed or flat, in any position, up to 1400 lb. Lifting arms adjustable within range spreads 18 to 46 and 23 to 60 in. *Lewis-Shepard Products Inc., Watertown, Mass.*

ELECTRIC TRUCK: Capacity, 4000 lb. Has offset drive and stabilizing caster arrangement; operates in narrow hand truck aisles and turns at right angles from aisles narrower than overall length of truck and load. Powered by 12-v, 400 amp-hr battery. Has rubber tired wheels. Available in 6, 9 and 11 in. lowered heights; features standard 4-in. lift. Platforms made in 18 and 24 in. widths, 30, 36, 42 and 48 in. lengths. *The Raymond Corp., Greene, N. Y.*

TRAILER: All steel medium duty unit for handling bagged material or to carry one or more pallets loaded with bagged material. Has rounded corners and edges; furnished with cushion rubber wheels. Ends equipped with removable tubular racks. Loops on each side for diagonal type coupler rods, which permit backing with a tractor without jack-knifing. Capacity, 3000 lb; length, 69 in.; width, 36 in.; height of end racks, 23 in.; height deck from floor, 14 in. *Market Forge Co., Everett, Mass.*

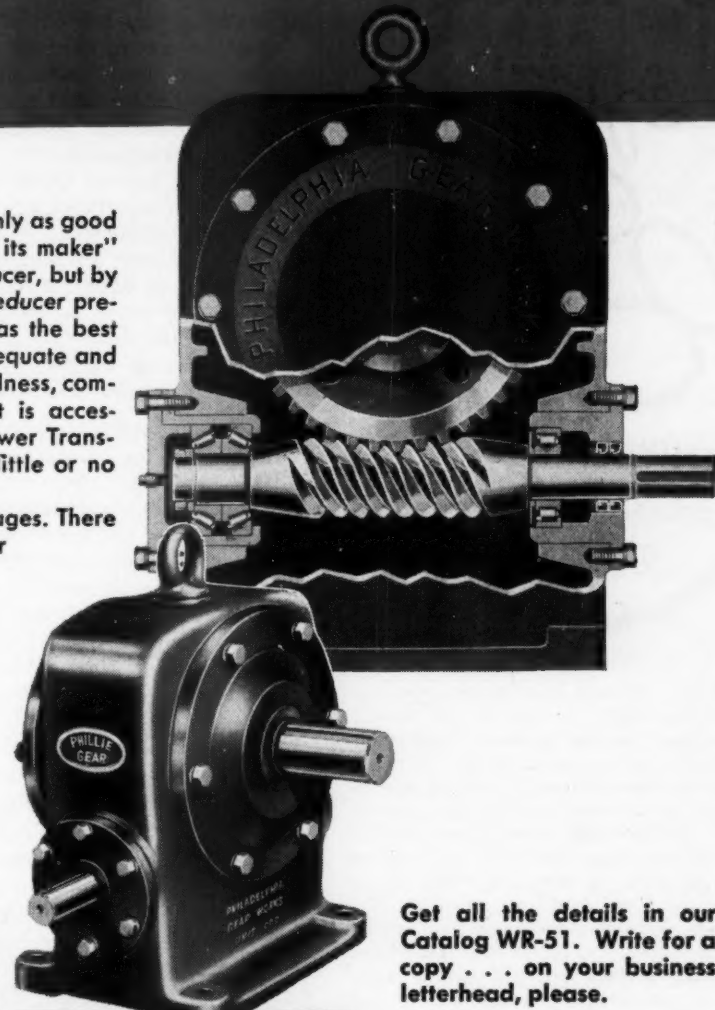
DRUM HANDLING DEVICE: Horizontal unit can be attached to any industrial fork truck without removing forks or making any hydraulic or mechanical connections. Fits over forks and is fixed to them with two screw type clamps. One or two standard drums can be picked up by lowering unit over them while truck is slowly backed away. Rear clamps are spring loaded and snap under lip of drum. Gravity action locks clamping hooks in place when drums are lifted. Drums can be stacked to any height within lifting range of truck. Weight of unit, 270 lb. *Yale & Towne Manufacturing Co., Philadelphia.*

PLATFORM ADAPTER: Converts Towmotor Model W electric pallet truck into platform truck; makes possible handling of platforms, skids and tote boxes. Steel framework construction. Folds up over battery when not in use. Height of forks with adapter, 7 in. in lowered position; 11 in. raised. For use on trucks powered by lead-acid batteries under 27 in. long; available in lengths to match standard pallet truck forks up to 72 in. long. *Towmotor Corp., Cleveland, O.*

SKID ADAPTER: Enables conventional hand pallet truck to lift and handle skid platforms. Hinged superstructure can be raised out of the way when handling pallets or lowered into position when handling skid platforms. *The Raymond Corp., Greene, N. Y.*

DIE HANDLING UNIT: Power winch mounted in battery compartment of Baker JOM series fork trucks of 7000, 8000 and 10,000 lb capacities converts trucks into die handling machines without interfering with hauling and tiering efficiency. All parts of winch except reels and cables are enclosed in battery compartment. Cables from winch to die are guided over rollers on side plates of truck. For die pulling, hooks on winch cables are attached

There's *far more* to a SPEED REDUCER than GEARS



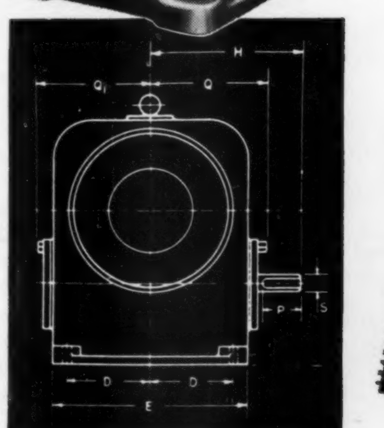
It has frequently been said that: "any Reducer is only as good as the *experience and manufacturing facilities* of its maker" . . . *Gears are vitally important* in any Speed Reducer, but by themselves, they are *just Gears. A good Speed Reducer* presupposes also that it is properly engineered; it has the best anti-friction Bearings; the lubrication system is adequate and highly efficient; the Housing is designed for ruggedness, compactness and proper heat dissipation. The Unit is accessible—and it will deliver a high efficiency of Power Transmission over a long period of service life, with little or no attention.

Philadelphia Reducers offer all of these advantages. There is a type and size of Philadelphia Worm Reducer for every industrial requirement.

FEATURES . . .

OF THE TYPE A-T-O AND R-T-O PHILADELPHIA WORM GEAR SPEED REDUCERS

- Units are available with Worm "above" or "below" the Worm Gear, or in Vertical Units.
- Worms are made of alloy steel with carburized, hardened and tempered threads—both shaft and threads are accurately and smoothly ground after heat-treatment.
- Worm Gears are of highest quality chill cast nickel-bronze.
- Bearings are anti-friction types (ball or roller) best suited for smooth, quiet, trouble-free operation (see cut-away illustration).
- Housings are quality grey iron—compact, neat, rigid and of ample radiating surface to prevent overheating.
- All units carry A.G.M.A. rating.
- Easy accessibility for removal of either Worm or Worm Wheel assemblies, from the housing.
- Lubrication by splash system to all moving parts, in oil-tight housing.
- Efficiencies as high as 96%.



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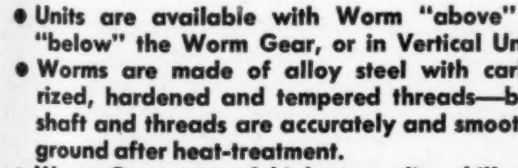

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Industrial Gears and Speed Reducers
LimiTorque Valve Controls

to die. Power is applied to winch to pull die onto the forks. *The Baker-Raulang Co., Cleveland, O.*

Plant Equipment

DUST COLLECTOR: For out-of-doors exhaust of air cleaned of industrial dust but still containing toxic fumes. Recommended for dust produced in buffing, polishing, woodworking, chemicals, etc., or from conveying, mixing handling or boxing of various types of materials. Capacity, 2450 cfm on a single 6-in. inlet, with a 4.5-in. static suction. Size of outlet, 8 in. Available for 220 or 440-v, 3-phase, 25-cycle motor. Floor space required, 22 by 40 in.; overall height, 78 in. *Aget-Detroit Co., Ann Arbor, Mich.*

ATMOSPHERE GENERATOR: Provides atmospheres for clean nondecarburized hardening, dry cyaniding or carbonitriding, carburizing (carrier gas), copper and silver brazing, nitriding, sintering and bright annealing. Delivers 150 cu ft of atmosphere per hour. Consists of ammonia cracker housed in a fabricated steel cabinet. Complete unit includes an electric tube type furnace with automatic temperature control, catalyst filled alloy retort, necessary piping and flow regulation accessories. *Hevi Duty Electric Co., Milwaukee, Wis.*

FABRICATED STEEL BLOWERS: Models range up to 200 hp. Multistage model SG and single stage model SM operate at 3500 rpm; model ST operates at 1750 rpm. Standard outlet pipe sizes range from 4 to 24 in., all flange fitted. Designed for air only, units can be adapted to use of corrosive, poisonous or explosive gases. Delivers air pressures up to 3 psi. Constant pressure maintained irrespective of air volume. Power consumption directly proportional to air volume. Used for industrial vacuum cleaning systems, pneumatic material transport, carburetion for combustion, foundry and blast furnace work, liquid aeration and agitation, and gas or air circulation. *Billmyre Blower Division, Lamson Corp., Syracuse, N. Y.*

Testing and Inspection

HYDRAULIC TEST STANDS: For testing flexible hose used in aircraft; can be adapted to testing of valves, cylinders and other equipment. Provides test pressures up to 5000 psi, using large volume pumps, and up to 30,000 psi with special booster equipment. Can include accumulator, cycling equipment and timing devices, and can employ any type of hydraulic oil. *Superdraulic Corp., Detroit, Mich.*

WINDING INSULATION TESTER: Redesigned 10-kv unit for detecting insulation faults and winding dissymmetries in motors, generators and coils. Consists of repeating-type surge voltage generator, cathode-ray oscillograph and synchronously driven switch for alternately reversing direction of surge travel through the winding. Surge generator capacitance, .05 mf; voltage, 0.2 to 10 kv, adjustable in 2 per cent steps; current capacity, 100 amp. Tests motors up to 2000 hp, 2300 v, as well as miscellaneous small and medium sized coils and d-c armatures up to 20 hp, 220 v. *General Electric Co., Schenectady, N. Y.*

HOSE TEST STAND: Provides permanent records of hose assembly tests. Tests complete aircraft hose assemblies for cycle and impulse in accordance with MIL-H-5511 and MIL-H-5512 specifications; makes burst test up to 25,000 psi. Housed in three-compartment cabinet containing test chamber, electronic equipment and oil reservoir, pumps, motors and controls. For laboratory use. *Sprague Engineering & Sales Corp., Gardena, Calif.*

Transportation

TRUCK TRAILER: Six-ton, single-axle cargo unit. Body is bolted instead of welded to chassis, making possible use of chassis as base for platform trailers, stake and rack trailers and trailer vans. *Trailmobile Inc., Cincinnati, O.*

MOTORCYCLE: Features four-speed foot shift, wider tire-tread contour and Parco-Lubrized exhaust valves. Booster spring assembly aids operation of clutch hand-lever by overcoming pressure required to disengage the clutch. Weighs less than 200 lb; averages 90 miles per gallon of fuel. *Harley-Davidson Motor Co., Milwaukee, Wis.*

Woodworking

PLANER-MOLDER-JOINTER: Model 465 makes variety of moldings or planes as it joints. Planes lumber up to 4½ by 11 in. Has machined table surfaces; recessed straight edge. Spring steel hold-downs with finger-tip controls hold wide, narrow or uneven stock. Arbor rides on ball bearing units. Molding knives can be mounted in several positions. Upper table is jointer attachment; has true right angle fence with two extension rods. Lower table is used under cutter-head to plane or mold. Planer table size with extensions, 27 by 7½ in.; weight of machine, 64 lb. *Toolkraft Corp., Springfield, Mass.*

1951 ANNUAL INDEX

Volume 23

January to December

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V

* Denotes short articles of less than one page.

W

Z

Here's the way to
Check the Most Accurate Gears
That Can Be Made

Kodak Conju-Gage Gear Checker, Model 8U, tests gears up to 8¼ inches in pitch diameter. Smaller models check gears up to 1¼ and 4⅛ inches, respectively.

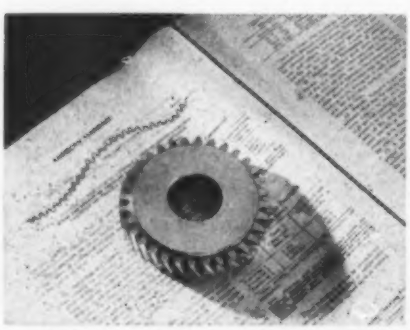
With Kodak Conju-Gage Gear Checkers, you get a composite check which meets the most exacting precision tolerances as recommended in the new American Standard.

This new kind of gaging instrument checks the composite effects of runout, base pitch error, tooth thickness variation, profile error, and lateral runout, as well as taper, crown, and lead error. You have a completely dependable precision evaluation of both your generating process and finished gears—in one fast operation.

The key is in the Kodak Conju-Gage Worm Section. Its uncomplicated form permits grinding to tolerances almost impossible to achieve in circular master gears. Your own toolroom procedures can keep check on its accuracy. And unlike circular masters it can be reground to original specifications and precision, if necessary.

A single Kodak Conju-Gage Worm Section can be used to check spur or helical gears of any helix angle or any diameter, provided they have the same normal pitch and pressure angle. Results are permanently recorded to ship with gears or to hold for future reference.

If you're finding it difficult to meet specified tolerances it will pay you to investigate the Kodak Conju-Gage Gear Checker. For your copy of the informative booklet, "Kodak Conju-Gage Gear Testing Principle," write to Eastman Kodak Company, Industrial Optical Sales Division, Rochester 4, New York.



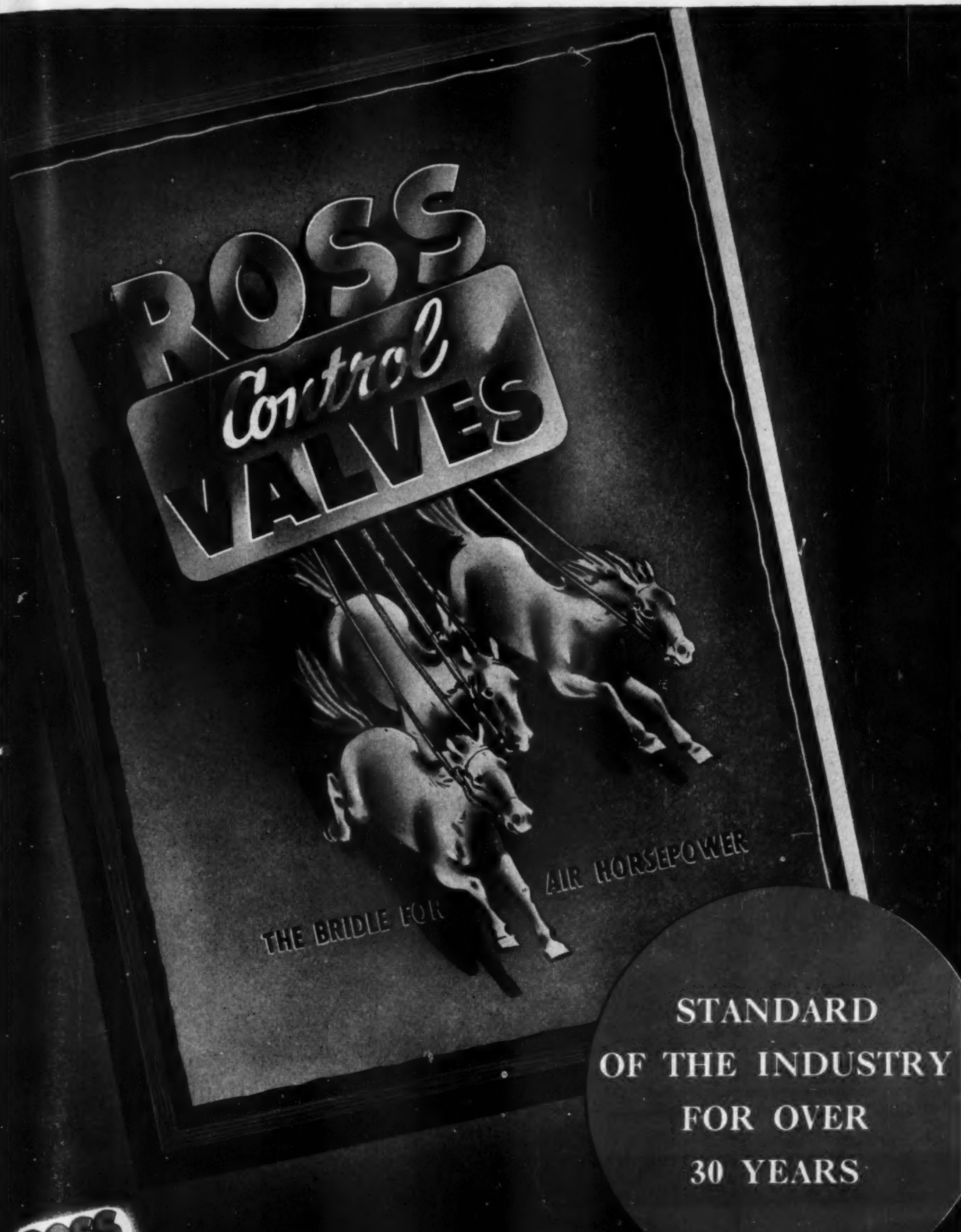
The new American Standard, "Inspection of Fine Pitch Gears," recommends the composite gear-check principle. Class 3 tolerance for precision fine pitch gears calls for a tooth-to-tooth composite error no greater than .0002", a tolerance easily checked with Kodak Conju-Gage Gear Checkers. A copy of this helpful booklet will gladly be sent on request.

CONJU-GAGE INSTRUMENTATION

...a new way to check gear precision in action

To inspect all kinds of complex parts on a bright screen, Kodak also makes two highly versatile contour projectors.

Kodak
TRADE-MARK


ROSS
Control
VALVES
THE BRIDLE FOR AIR HORSEPOWER
STANDARD
OF THE INDUSTRY
FOR OVER
30 YEARS

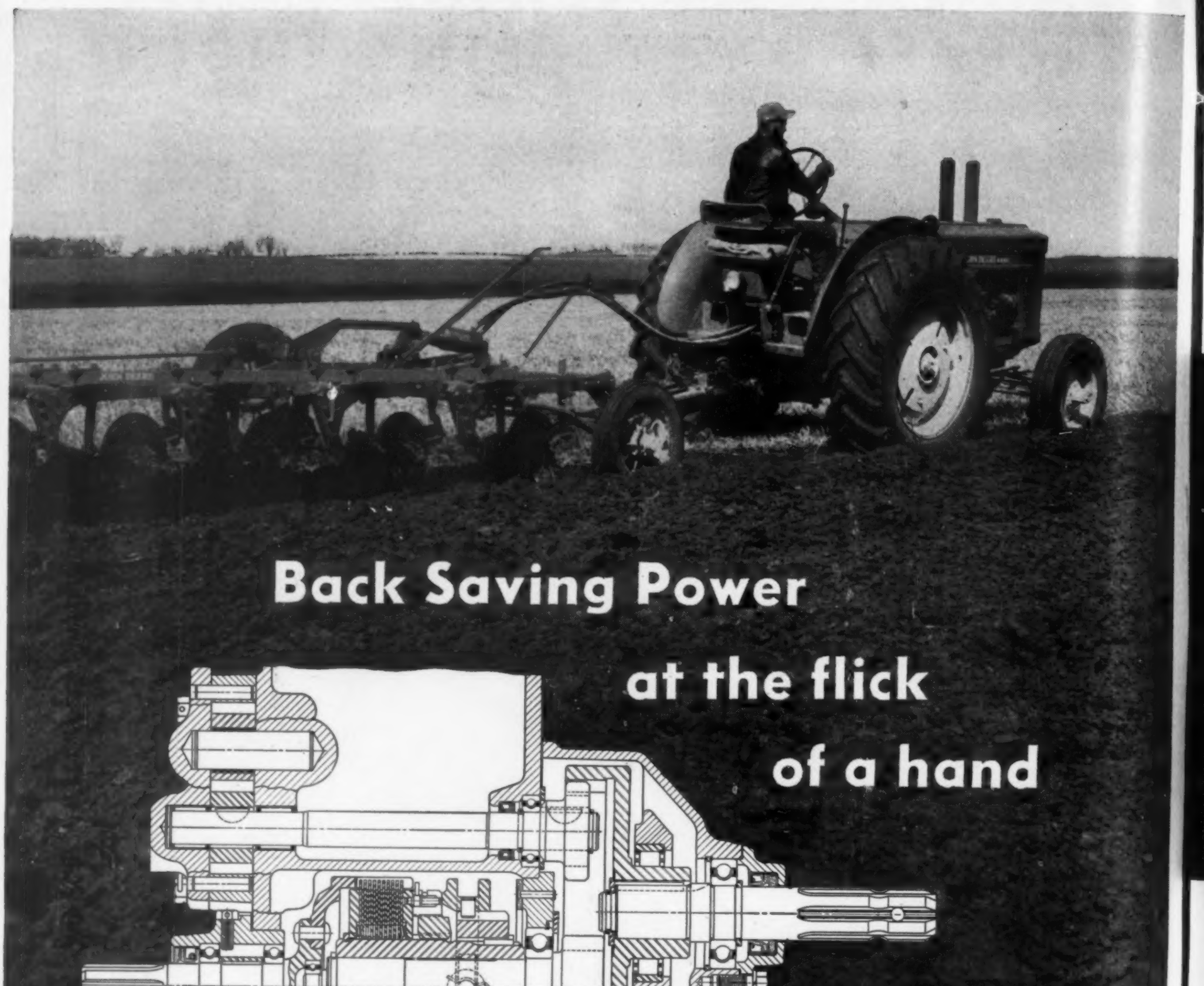
AIRCRAFT GAS TURBINE ENGINES USE INTERCHANGEABLE

GLEASON CURVIC® COUPLINGS

Ground Curvic® and Zerol face couplings are produced automatically on the Gleason No. 19 Curvic® Coupling Grinder with a uniformity which makes each part interchangeable. Use of self-centering built up sections, perfectly aligned through fixed coupling teeth, simplifies manufacture and materially facilitates reassembly of large units to their original standard of precision.

GLEASON WORKS

1000 UNIVERSITY AVENUE · ROCHESTER 3, NEW YORK



SHAFTS on smooth running New Departure ball bearings get *maximum* power right thru to where it is needed season after season without change — and *that* is what tractor owners really appreciate.

In the John Deere Model R Diesel, New Departures on the independent clutch, power take-off and hydraulic pump shafts assure back saving power at the flick of a hand for raising, lowering, angling or driving of attachments.

New Departure, Division of General Motors Corp., Bristol, Connecticut.

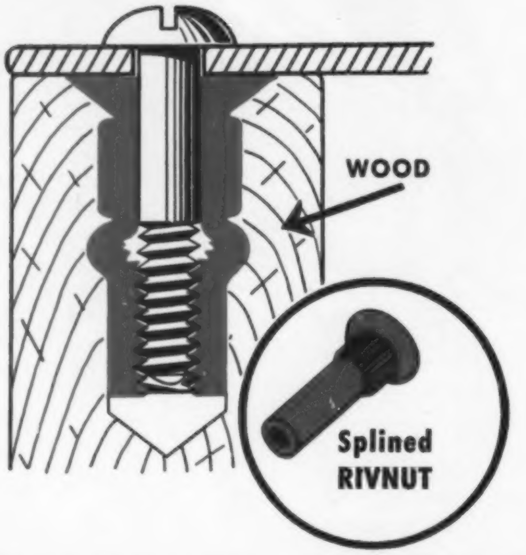
Direct engine-driven Power Take-off and Hydraulic "Powr-Trol" pump for operation of attachments to the John Deere Model R Diesel Tractor are engaged or disengaged at will by an independent clutch.

Nothing Rolls Like a Ball

NEW DEPARTURE BALL BEARINGS

158

RIVNUT set in wood provides 6 clean threads for TV fastening job



Using wood screws to fasten the back of television sets is unsatisfactory because frequent removal of the screw quickly wears away the wood. This problem was solved for one leading manufacturer by splined Rivnuts. Imbedded and upset in the wood frame, Rivnuts provide at least six clean metal threads for screw attachment. Bulge formed by upsetting holds Rivnut fast. Splines take care of torque.

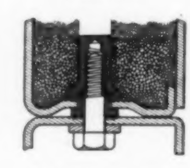
The splined Rivnut is only one of many types of Rivnuts that solve tough fastening problems in wood, metal, plastics, many other materials. Consult a Rivnut engineer for help with *your* fastening problem. The B. F. Goodrich Co., Dept. MD121, Akron, Ohio.

What's your toughest fastening problem?

TORQUE?

Special Rivnuts with splined shafts or key (above) supply needed torque resistance.

SEAL?



Firm grip of upset Rivnut on material, plus special closed end, gives tight seal.

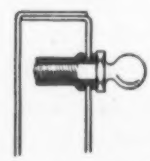
MATERIAL?

Even in thin materials, Rivnuts provide at least 6 threads for attachment.

ATTACHMENT?

Fasten *with* Rivnuts—fasten *to* Rivnuts. Makes possible multiple fastening.

FINISH?



Rivnuts can be installed after paint or porcelain finish is applied.

LOAD?

Typical Rivnut thread strength: 6-32—964 lbs.; 8-32—1096 lbs.; 10-32—1326 lbs.*

RIVNUTS *lick them all!*

**Figures given for aluminum. Loads for brass and steel Rivnuts about double.*

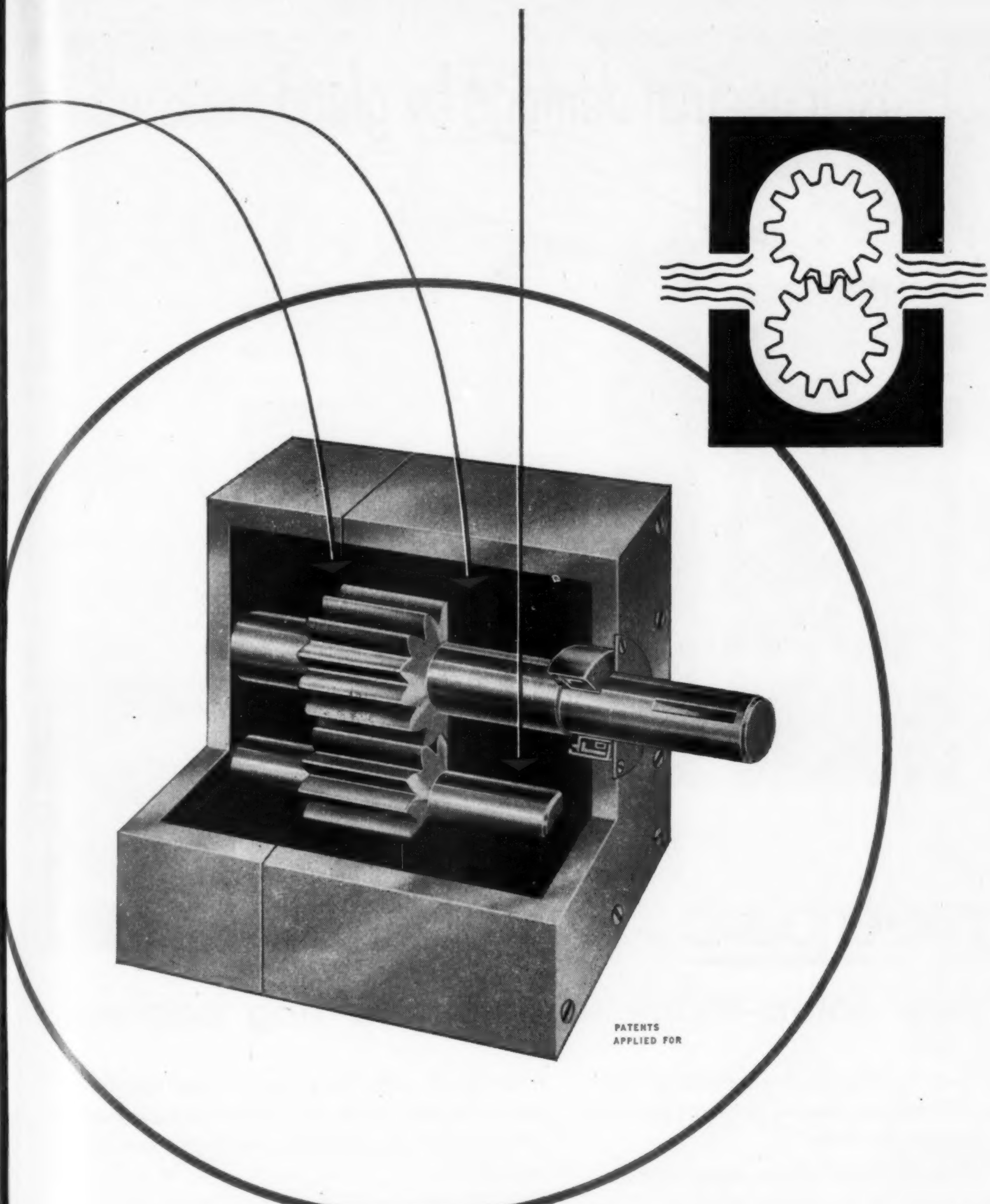
B.F. Goodrich

RIVNUTS

The only one-piece blind rivet with threads

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Shows with motion how Rivnuts work. Explains construction, gives proved applications. Write to The B. F. Goodrich Company, Department MD121, Akron, Ohio.



165

Uneepac...

the new Johns-Manville automatic ring packing

HERE AT LAST is an automatic ring packing that's designed to eliminate one of the most common causes of packing failures!

A glance at the cross section above will show you why. Note the projecting portions of the center section of each Uneepac ring. These projecting "legs" provide an effective safeguard against damage by excessive gland pressure. Header and follower rings are therefore seldom required.

Another important advantage is also provided by this unique design. Each Uneepac ring centers itself on the preceding ring so that the entire set is aligned vertically and nested perfectly. This feature practically insures trouble-free installation.

If you are looking for an automatic ring packing that seals effectively in a minimum of space . . . operates with a minimum of friction . . . and is instantly responsive to fluid pressure changes . . . you will want all the facts about Uneepac. Bulletin PK-58A is free for the asking. Just address Johns-Manville, Box 290, New York 16, New York.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PACKINGS & GASKETS

Lassman HYDRACTORS

For Any Application Where You Want a STRAIGHT LINE MOTION under POWER

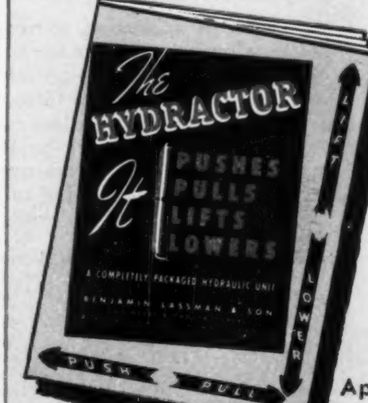
The Hydractor is designed and engineered to produce a completely self-contained, heavy-duty Hydraulic Linear Actuator. It can be mounted and operated in any position since all parts are assembled to form a packaged unit with a sealed Hydraulic system ready for installation.

Being self-contained, it eliminates the assembling of separate components, pumps, valves, fluid reservoirs and piping, to produce a composite system.

It is as easy to install as an electric motor. Just bolt in place and make the necessary electrical connections.

The simplicity of the Hydractor results in a minimum amount of engineering by users for a given application. Force, speed and space requirements are the only factors that need to be determined.

Sales Territories Are Open for Acceptable Representatives



Patent Applied for

BENJAMIN LASSMAN & SON

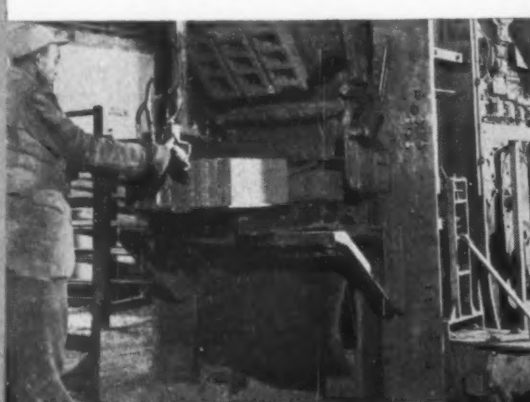
ENGINEERS & MANUFACTURERS SINCE 1921

421 OLIVER BUILDING • PITTSBURGH 22, PA.

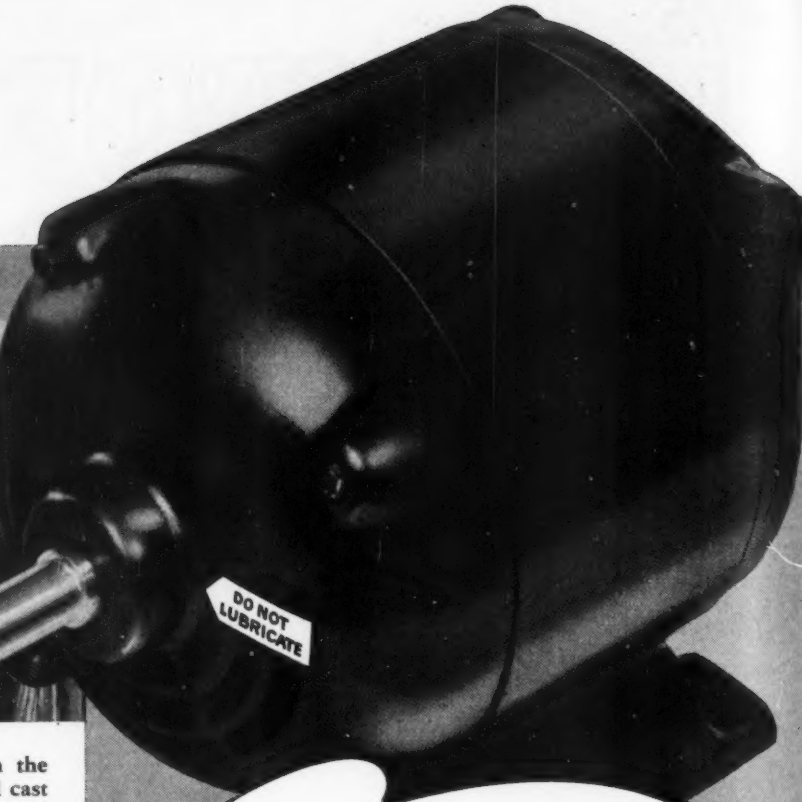
Write for Bulletin 551

It points out the specific features of the HYDRACTOR. It enables you to select the model for your application.

Murderous shock duty is imposed on the motor on this log barker. Conventional cast motors broke shafts, feet, brackets. The steel frame Life-Line stands up . . . has reduced outages to zero . . . saved costly replacement.



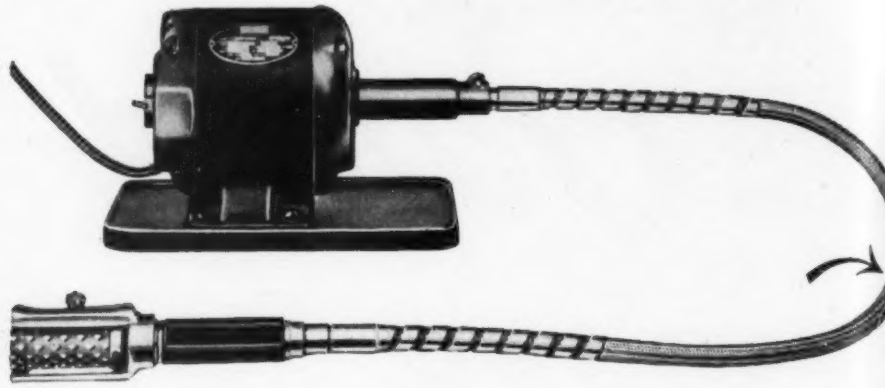
Other makes of starters, previously tried, couldn't "stand the gaff" on this cinder block-making machine. Here, where vibration is severe, standard Life-Linestarters performed without fail. Operation requires opening and closing of starter over 240 times every hour.



FOR THE BEST DESIGN

USE *Life-Line*

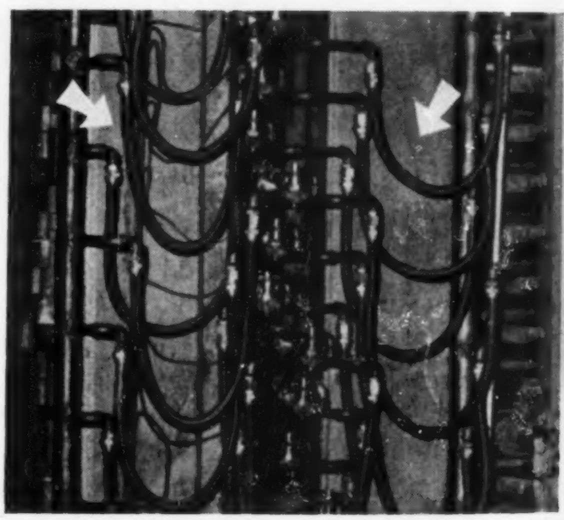
If your product calls for action from connectors...



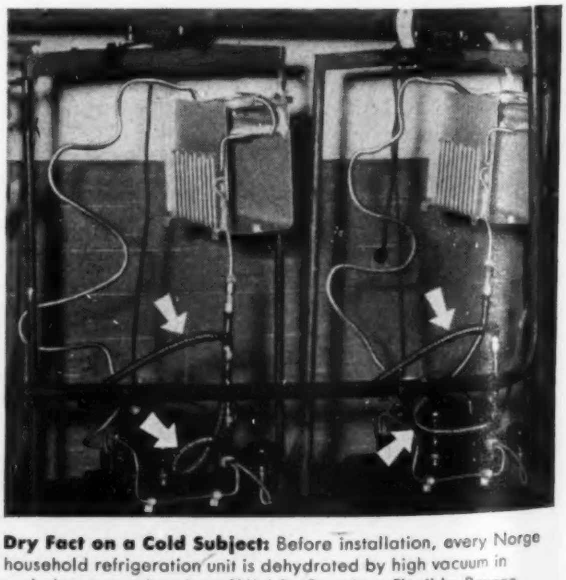
Fish Story: What could be easier than scaling a fish—if you use this model FSB Fish Scaling Machine made by The Balmar Corp., N. A. Strand Div., Chicago? The flexible shaft driving the cutter is protected in $^7/_{16}$" I.D. American Type SL Flexible Steel Hose jacketed with an outer braid.

Use American Flexible Metal Hose or Seamless Tubing—the completely flexible metal connectors—where piping connectors move or vibrate; where ports are misaligned or for piping in cramped spaces where there's little room to work.

American Flexible Metal Hose and Tubing are available for carrying almost any liquid, gas or semisolid under severe conditions of corrosion, temperature, pressure and mechanical stress. You'll find full details in Bulletins SS-50 and CC-300. We would like to send you copies. The American Brass Company, American Metal Hose Branch, Waterbury 20, Connecticut. In Canada: The Canadian Fairbanks-Morse Co., Ltd. Distributors in all key cities. 51242



Sandwich Maker: Sheets of plywood are bonded under heat and pressure. Heat for this Mesco hot-plate press of the Harbor Plywood Corp., Aberdeen, Wash., is provided by steam carried to the 21 platens in ½" I.D. American Seamless Flexible Bronze Tubing with single bronze braid.



Dry Fact on a Cold Subject: Before installation, every Norge household refrigeration unit is dehydrated by high vacuum in a drying oven. American ¼" I.D. Seamless Flexible Bronze Tubing connects each unit to the vacuum manifold. Specifications call for leakproof, corrosion-resistant tubing able to operate under 31" vacuum at an oven temperature of 280°F for 4 to 6 hours.

wherever connectors must move...

American

ANACONDA

FLEXIBLE METAL HOSE AND TUBING

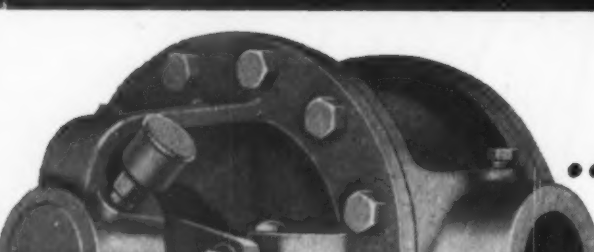
when the ACCENT is on the Positive.

. . . then the positive pumping of Fairbanks-Morse Rotary Pumps offers the best choice for your equipment. They efficiently handle any free-flowing liquid from gasoline to molasses with exceptionally high efficiency. Non-fluctuating load characteristics minimize shock and vibration . . . assure long, economical service.

Only TWO parts move in Fairbanks-Morse Rotary Pumps . . . a precision-cut rotor and pinion gear. There are no complicated parts to cause trouble or to require frequent maintenance and adjustment. Capacities range from ⅜ to 5 inches. If your design problems involve positive pumping, choose from the Fairbanks-Morse Rotary Pump line . . . the economical choice.

FAIRBANKS-

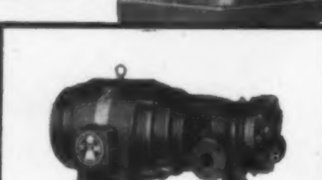
A NAME WORTH



..when HEADS are up or down

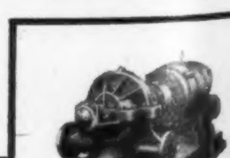
A Fairbanks-Morse Westco turbine-type pump is the efficient answer. The unique design employed in these exceptionally compact pumps permits them to handle widely varying heads with little or no loss of capacity. Maximum capacity is obtained at an operating speed of 1750 r.p.m. when discharging at low pressure, and high pressures are developed at the same speed with little change in capacity. In addition, through the use of a single-stage, multi-vaned impeller, Westco Pumps give you multi-stage performance from a single-stage pump. Westco Pumps are widely used as integral parts of machines, units or systems. Capacities from 1 to 200 g.p.m. Check them for your equipment.

Other FAIRBANKS-MORSE Pumps Include



Builtogether Centrifugals

Side-Suction Centrifugals



Single and Two-Stage Centrifugals

Cross Flow Ventilation... Copper Spun Rotor

... OTHER UNIQUE FEATURES

Cross Flow Ventilation is an exclusive Fairbanks-Morse design that eliminates hot spots, prolongs the life of the stator installation.

Copperspun Rotor: a truly one-piece indestructible copper winding that withstands higher temperatures, has high electrical and thermal conductivity, better dynamic balance.

Rugged Frame Construction: Protection in any mounting position.

General purpose continuous duty: rated 40° C. and designed to carry 115% load continuously without injurious heating (1.15% service factor).

High efficiency, high power factor, good starting and accelerating torques.

Unique conduit box provides alternate assembly: either recessed, flush with frame or conventional external mounting.

Mounting dimensions conforming to NEMA standards.

Arrows show double flow of air that keeps motors running cool!

s MORSE

h REMEMBERING

THESE ARE YOUR FAIRBANKS-MORSE SALES CENTERS

ATLANTA 3, GEORGIA
760 Lee St., S. W.
AMhurst 7701

BALTIMORE 18, MD.
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BElmont 5258

BIRMINGHAM 1, ALA.
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3-6546

BOSTON 10, MASS.
178 Atlantic Avenue
LAfayette 3-3600

BUFFALO 3, N. Y.
33 Franklin St.
Lincoln 4210

CHARLOTTE 2, N. C.
Liberty Life Bldg.
Room 605
6-2893

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HArrison 7-7100

CINCINNATI 2, OHIO
49 Central Avenue
MAin 3010

CLEVELAND 14, OHIO
3000 W. 117th St.
CLearwater 1-3300

COLUMBUS 8, OHIO
1034 Goodale Blvd.
WAlnut 8581

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1713 N. Market Street
CEntral 4347

DENVER 2, COLO.
1500 17th Street
TAbor 6241

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2017 Dean Avenue
6-1189

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VAlley 1-7100

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CAlhoun 1469

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SChenley 1-3123

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EAst 0131

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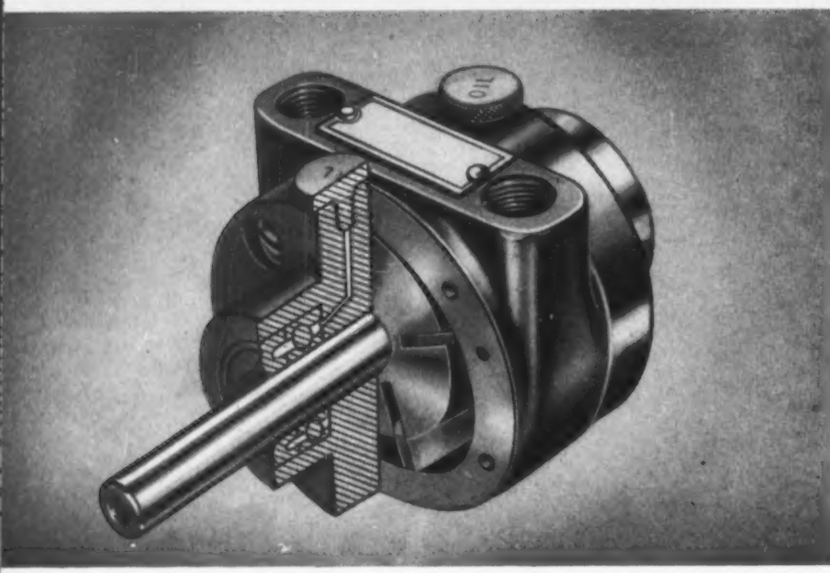
applications unlimited for

AIR PRESSURE and VACUUM

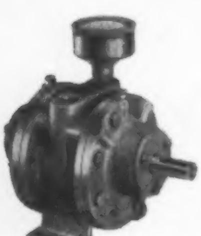
on a multitude of industrial products



• to simplify design
• to reduce costs
• to improve performance

GAST rotary-vane design has many advantages . . .

1. No piston rings—no hinged parts, rockers, counterweights, reciprocating parts, etc., to wear out or require adjustment.
2. Air delivery is continuous and pulseless.
3. A rotor and four sliding vanes are the only moving parts.
4. Centrifugal force holds vanes tightly against housing for an efficient, uniform seal.
5. Vanes take up their own wear automatically.
6. Forced air fan cooling insures long life, oil economy, no hot-oil odor.
7. Automatic oiling insures continuous lubrication, minimum wear.
8. Automatic shaft seal requires no packing.
9. Rugged bearings insure long life.
10. Greater reliability, less maintenance, lower first cost.



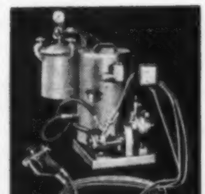
NEW Model 8 AM ROTARY AIR MOTOR
½ to 4 h.p.—6 types

Any one of the 6 design variations can be ordered to suit your application. Reversible and non-reversible models. The reversible motor is ideal for frequent stop-and-start applications in slower speed ranges. The non-reversible rotates counterclockwise. May be operated above 2000 r.p.m., delivering up to 4 h.p.

Here's how GAST rotaries deliver valuable benefits as original equipment on your products . . .

First, you stand to benefit from Gast's background of experience (over 25 years of it) in engineering Gast Rotaries for use on hundreds of different product applications. In addition, the basic simplicity of Gast rotary-vane design delivers unique performance advantages with efficiency and dependability. Then, because our customers have built a large demand for models **you** may want to use, costs are lower on a choice of over 200 different assembly models. Air power, air pressure or vacuum in the lower capacity ranges may give you specific worth-while advantages over mechanical, electrical or hydraulic methods of doing your product job. Get the complete story—"Air may be your Answer!"

GAST rotary air motors are compact, explosion-proof, variable in speed



On this Bede Circulating Paint Heater, designed for faster application of hot finish, a Gast Air Motor running below 500 r.p.m. drives liquid pump. It's explosion-proof and safe—uses less than 30 p.s.i. air pressure.

On this Conveyor-Belt carrying fragile material, a variable-speed 1 h.p. Gast Air Motor automatically reduces speed, compensating for uneven drag of load to maintain constant tension on material in process. Over-loads can't burn out a Gast!

GAST rotary air pumps for pulseless pressure to 30 lbs., vacuum to 28 in.

On offset printing presses, vacuum-back cameras, and lithographer's printing frames, American Type Founders use several sizes of Gast Air Pumps for paper-feeding (both suction and air blast) and copy holding (suction only).

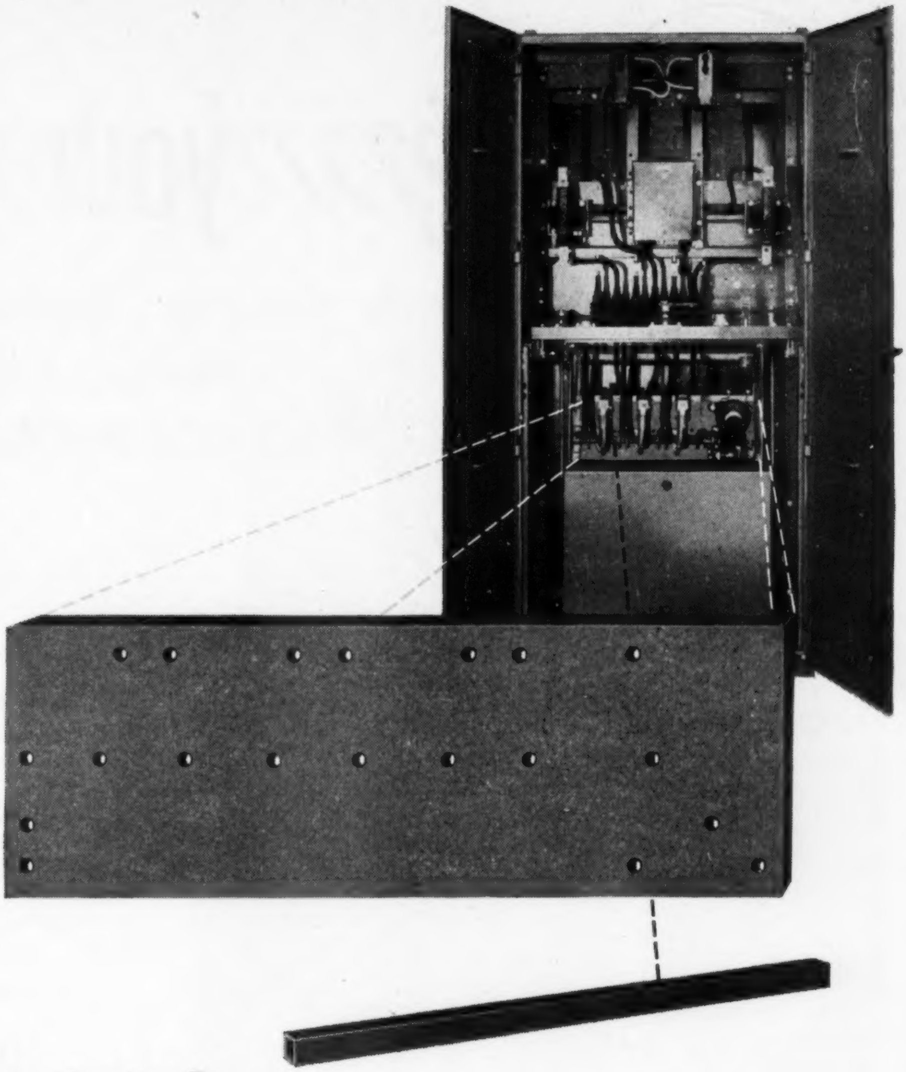
To remove aluminum bottle caps from magazine and hold ready for feeding, Aluma-SEAL specifies a positive-action Gast Air Pump producing 20 to 22 inches vacuum for feeding its bottle capping unit.

Original Equipment Manufacturers for Over 25 Years

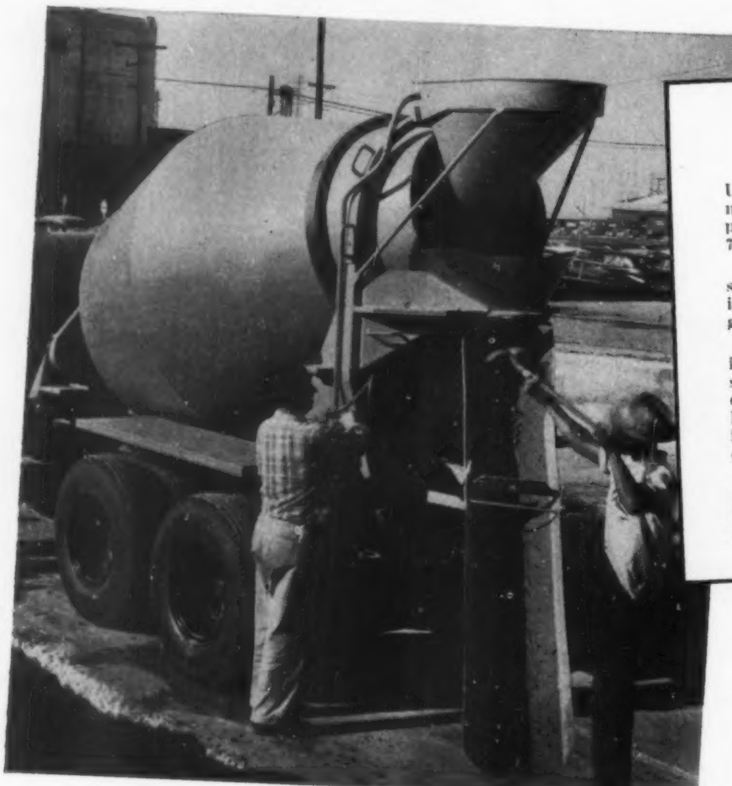
GAST ROTARY — AIR MOTORS · COMPRESSORS · VACUUM PUMPS
(TO THREE H.P.) (TO 30 LBS.) (TO 28 INCHES)
GAST MANUFACTURING CORP., 107 Hinkley St., Benton Harbor, Mich.

See our CATALOG in SWEET'S FILE

Gast application Ideas Booklet, showing 26 different design problems solved, will be sent on request.



Design your equipmen



U·S·S COR-TEN

U·S·S Cor-Ten is a ductile, low-carbon chromium-nickel-silicon-copper-phosphorus steel having a yield point of 50,000 psi min., and a tensile strength of 70,000 psi min. in thicknesses ½" and under.

Its resistance to abrasion and shock is superior to structural carbon steel; its fatigue resistance—that is, its ability to withstand repeated stresses—is 60% greater.

What particularly distinguishes U·S·S Cor-Ten is its unusually high resistance to atmospheric corrosion—4 to 6 times that of plain steel, 2 to 3 times that of copper steel. This property helps to assure the long life and low maintenance cost of any equipment in which Cor-Ten is used, whether to obtain greater durability or to reduce weight.

U·S·S Cor-Ten is produced in all standard products—plates, shapes, bars, sheets, strip, special cold formed sections and wire. Recommended particularly for application in light and intermediate thicknesses.

"We prefer U·S·S Cor-Ten," says Mr. Ross Castendyck of the Challenge Mfg. Co., Maywood, Cal., "because of its superior corrosion and abrasion resistance as well as its high strength. These permit us to reduce our Mixer weight 10% to 15% and at the same time to build a 20% stronger unit that will stay in service at a lower maintenance cost."

U·S·S MAN-TEN

U·S·S Man-Ten is a grade of manganese-copper steel that, at relatively low cost, provides toughness, workability and weldability in a higher degree than obtainable in carbon steel of the same strength level. Its atmospheric corrosion resistance is slightly higher than that of copper steel.

U·S·S Man-Ten, in thicknesses up to ½" inclusive, has a yield point of 50,000 psi min. and tensile strength of 75,000 psi min. Its abrasion resistance is greater than that of structural carbon steel (ASTM A7); its resistance to sudden shock is about 20% greater; its fatigue strength is approximately 40% higher, insuring greater ability to withstand vibration and reversal of stresses.

U·S·S Man-Ten is produced in plates, shapes, bars, sheets, strip, special cold-formed sections and other forms. It is particularly recommended for use in light and intermediate thicknesses.

U·S·S Tri-Ten has long been used to assure the dependability for which Caterpillar equipment is famous. The weight-saving and space-saving advantages in proportion to the strength of this steel has resulted in their engineers using it regularly.

Less Expensive Micronic Filter Saves Space . . . Works Mechanically

For fluid filtration in the micronic range, many designers are now specifying Cuno MICRO-KLEAN.

In many cases, the MICRO-KLEAN turns out to be the most efficient—as well as the most economical—method of filtering many fluids.

The MICRO-KLEAN cartridge is a simple, compact structure of "felted" fibres, with no internal or external supports to take up space and complicate installation. It gets its strength from the resinous impregnation and polymerization. It won't swell or shrink, soften or harden, rupture or channel, or otherwise release contaminants into the discharge flow.

Fewer cartridge changes

MICRO-KLEAN's greater dirt-holding capacity comes from maximum porosity (85-90%) and from its exclusive "graded density in depth", permitting smaller particles to penetrate further, rather than "loading" the surface.

Cuno MICRO-KLEAN handles a wide range of fluids and flow rates with low pressure drop. It is guaranteed to remove 100% of all solids for which it is rated plus a large percentage down to 1 micron.

Capacities: a few to over 800 gpm. Single or multiple cartridge units. External or built-in application.

Cuno Engineering Corporation
Dept. 201 C, South Vine Street, Meriden, Conn.

Please send information on Cuno MICRO-KLEAN for following installations ....

....

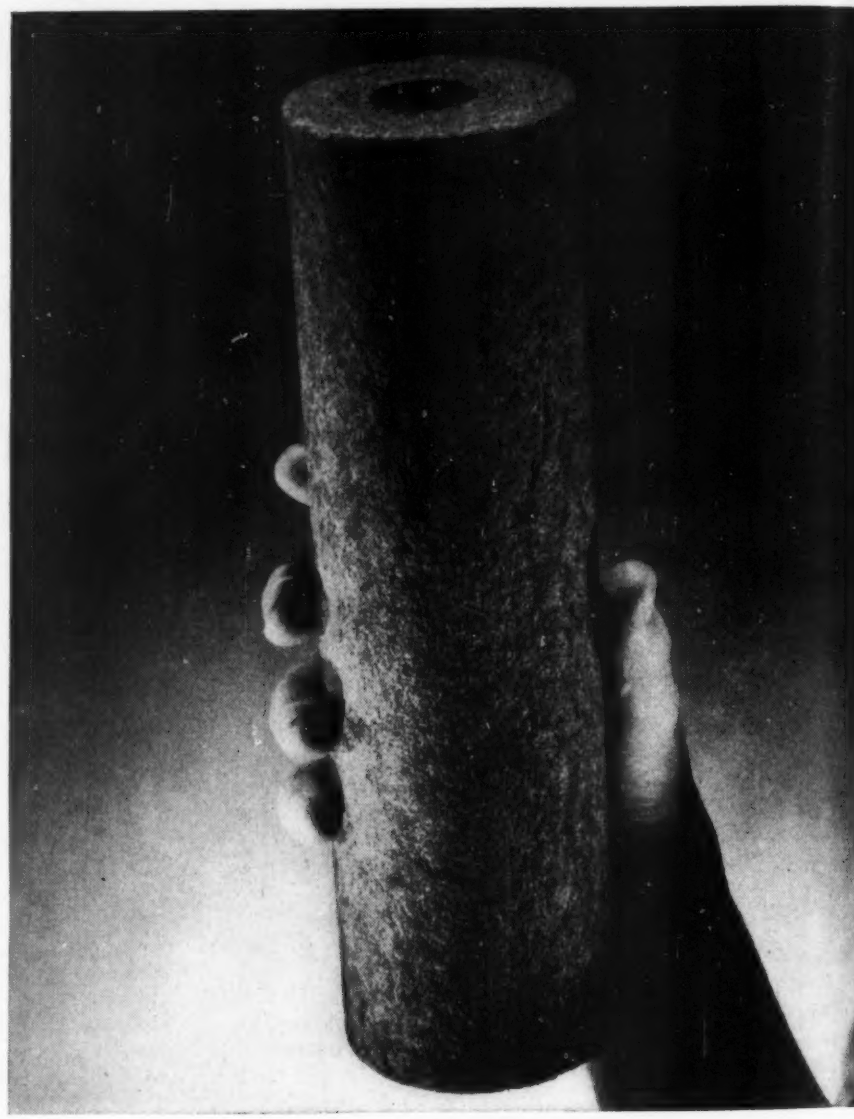
Name..

Company..

Address..

City...............Zone....State.....

Please attach to business letterhead



The Simplest Filter Cartridge Lasts the Longest...Twice as Long

Cartridge renewals are cut at least *in half* when Cuno MICRO-KLEAN replaces any other filter. And throughout its service life, MICRO-KLEAN is *guaranteed* for specific performance.

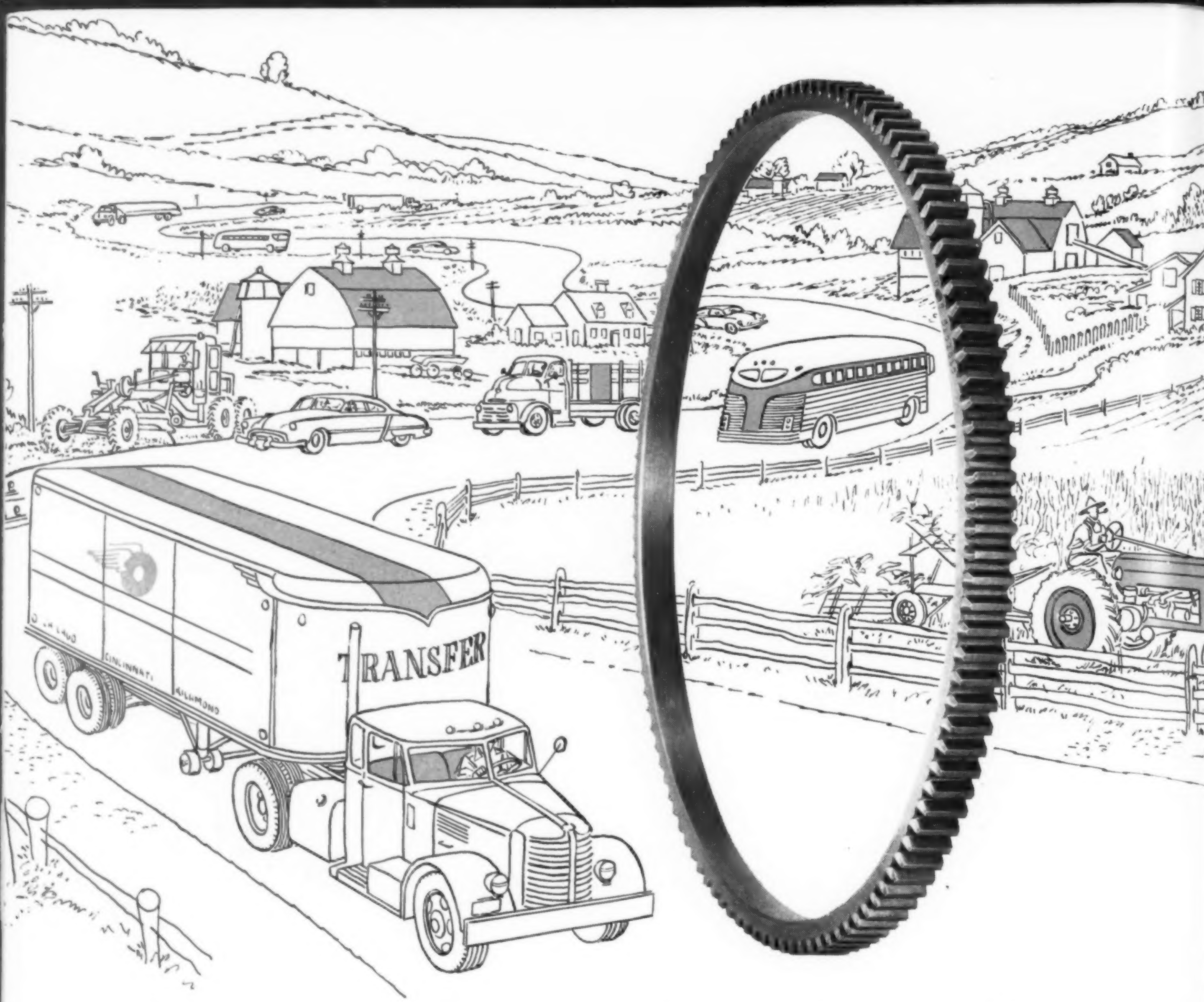
CUNO

Fluid Conditioning

Removes More Sizes of Solids from More Kinds of Fluids

Strain fuels, lubricants, process fluids, etc.—AUTO-KLEAN
Filter fuels, lubricants, process fluids, etc.—MICRO-KLEAN
Clean raw water, recirculating water, etc.—FLO-KLEAN

Six plants producing sleeve bearings in all designs and sizes; cast bronze bushings; rolled split-type bushings; washers, spacer tubes, precision bronze parts and bars.



Gears that start America rolling

The millions of motors that keep America rolling on farms and highways are silent and powerless until flywheel ring gears help turn them into action.

Building flywheel ring gears that dependably *start* a multitude of engines is a part of our gear-making responsibilities. In vehicles of practically every type —trucks, buses, passenger cars, road machinery, farm equipment, whether gasoline or Diesel powered—"Double Diamond" flywheel ring gears help *start* the wheels that keep America rolling.

IMPORTANT NOTICE TO PRESENT AND FUTURE CUSTOMERS

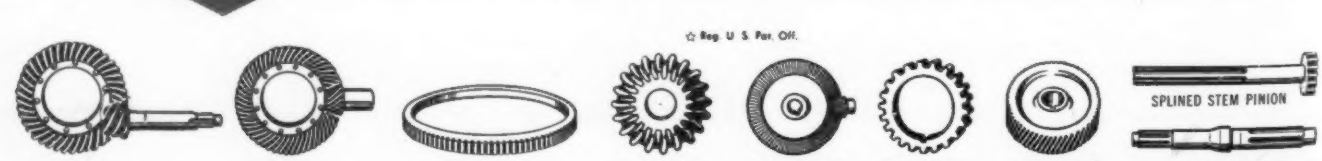
During the present abnormal period Automotive Gear Works believes its first loyalties are due its present customers, many of whom are directly or indirectly in defense work. For that reason, every effort will be made to first satisfy the growing requirements of those companies who are already users of "Double Diamond" Gears. Where facilities or materials permit, the requirements of prospective customers will receive careful attention, and technical assistance will continue to be made available for the solution of gear problems regardless of whether or not we are now in a position to build the gears recommended.

DOUBLE DIAMOND TRADE MARK GEARS

AUTOMOTIVE GEAR WORKS

RICHMOND, INDIANA

FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS



Further Information?

IF YOU DESIRE MORE INFORMATION ON ANY ADVERTISEMENT IN THIS ISSUE

Here's What You Do:

Write the name of the advertiser and the page number of the ad in the spaces provided on the card. Check the type of information you want—whether it has to do with price, where you can buy it, or more needed details—or all three, if you wish. After you have finished going through MACHINE DESIGN and have jotted down all the ads on which you'd like more information, just tear off the card and drop it in the mail. No postage is required. We'll have our staff forward this information immediately to the advertiser, so that you will be relieved of the necessity of writing a number of letters. You will then hear directly from the advertiser, answering your request. Because we know that MACHINE DESIGN gets around, and that more than one person sees your copy, we have made up three cards so that if you are one of the later readers, you can still have the opportunity of taking advantage of this service.

Please send further information on the following advertisements in this issue:

PAGE NO.	NAME OF ADVERTISER	Send Technical Data	Send Price Information	Nearest Source of Supply
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YOUR NAME ____________ TITLE ____________

COMPANY ____________

ADDRESS ____________

CITY ____________ STATE ____________

12-51

FIRST CLASS
PERMIT No. 36
(Sec. 34.9 P.L.&R.)
Cleveland, Ohio

BUSINESS REPLY CARD
No Postage Stamp Necessary If Mailed in the United States

4c POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

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the truth about Dow Corning Silicones...

. . . is more fantastic than the patter of the pitchman or the spiel of the barkers that doubled in advertising and sales a generation ago. For example:

- **Silicone (Class H) electrical insulation makes motors and other kinds of electrical equipment last 10 times as long as they ever did before.**
- **These same insulating materials are used to double the power per pound ratio in electric machines.**
- **Silastic,* the Dow Corning silicone rubber is used to seal hot air at 600°F., hot oil at 350-400°F., limit switches and bomb bay doors at —100°F.**
- **Dow Corning Silicone oils and greases make permanent lubrication a practical reality.**

To many engineers and executives, such silicone facts as these still sound too good to be true. That's why we have built and assembled 16,000 pounds of demonstration units and typical applications to prove that our silicone products will do all that we claim for them. This is the first comprehensive Silicone Exposition ever assembled. Previewed in Washington, D. C. during the week of October 22nd, this exhibit will be given private showings in major industrial centers across the country.

DOW CORNING SILICONE EXPOSITION
now scheduled for

CLEVELAND
DETROIT
PHILADELPHIA
NEW YORK
BOSTON
PITTSBURGH
CHICAGO
WICHITA
FORT WORTH
LOS ANGELES

If you want to know more about this Exposition write for complete information including our new 32-page book which answers in simple words and pictures, the $64 question, "What's a Silicone?" Address Department **P-12**

DOW CORNING CORPORATION
Midland, Michigan

ATLANTA
CHICAGO
CLEVELAND
DALLAS
LOS ANGELES

DOW CORNING SILICONES

*T.M.REG.U.S.PAT.OFF.

DOW CORNING CORPORATION **MIDLAND, MICHIGAN**

NEW YORK
WASHINGTON, D. C.

In CANADA: Fiberglas Canada, Ltd., Toronto • In GREAT BRITAIN: Midland Silicones, Ltd., London

Finishing Aluminum

Vitreous Enamels provide abrasion and heat-resistant coatings for aluminum. They adhere well, are easy to apply.

The sequence of operations for applying vitreous enamels on aluminum are: cleaning, spraying, oven drying, fusing the enamel frit at high temperature.

Parts are cleaned by wiping with cloths saturated with solvents or by vapor degreasing. Inhibited alkaline cleaners should be used. The enamel frits are mixed with water or turpentine, sprayed on and oven-dried. Quick drying by oven is important because the free alkali in the enamel mixture will cause surface corrosion if parts are left to air-dry.

The enamel is fused at temperatures from 940 to 1000° F. This heat will partially anneal temper rolled sheet. The heat treatable alloys will be partially heat-treated, but not to a full degree, because quenching is not possible.

Vitreous enamels on aluminum have the advantages of excellent resistance to impact and thermal shock. Certain coatings have exceptional resistance to mild acids.

For complete information on finishing Alcoa Aluminum write to the address below.

Aluminum Die Castings

The difference between average and exceptional die castings is often the kind of design help the supplier offers. Consider Alcoa's qualifications.

Alcoa offers the kind of technical literature and personal design consultation that you would expect from the leader in the aluminum industry and a die-casting supplier of 34 years' experience.

The help of an Alcoa sales-engineer is instantly available through your local Alcoa sales office. He is thoroughly familiar with the methods of applying aluminum die castings to your particular design problems. He will accurately interpret your production problems to the casting experts

ALCOA ALUMINUM ®

ALUMINUM COMPANY OF AMERICA • 1808M GULF BLDG., PITTSBURGH, PA.

at Alcoa's two modern die-casting plants. Often the simple suggestions that come from the close attention that Alcoa experts give your drawings can result in substantial savings and surprising increases in the performance of the finished product.

For the designer's technical library, Alcoa offers two books: "Designing for Alcoa Die Castings" — a 188-page book which covers all phases of design, machining and finishing. And "Machining Alcoa Aluminum" — a 67-page book which describes tooling, setup and machine speeds for all machining operations. Both books may be obtained through your local Alcoa sales office or by writing direct to the address given below.

Besides standard and special fasteners, Alcoa produces bushings, inserts for plastic and cast products, nozzles, valves, aircraft parts, electrical fittings, couplings, pipe and tube fittings.

Aluminum Fasteners

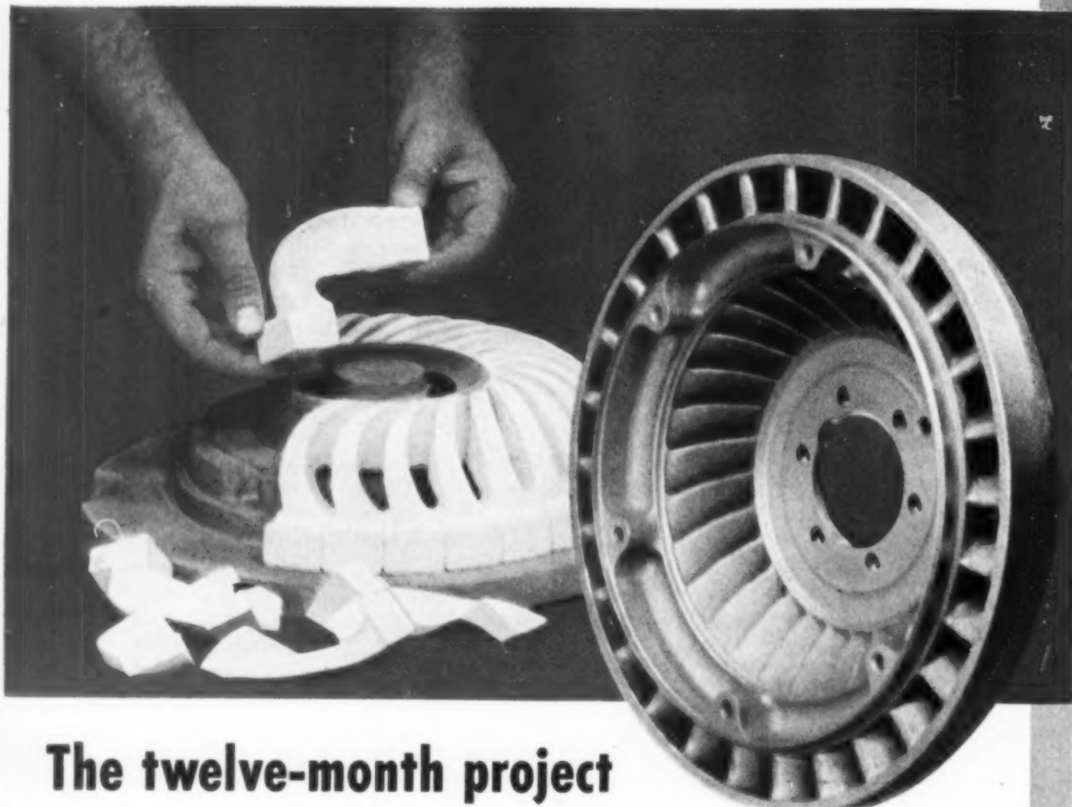
Alcoa supplements its complete line of standard fasteners with a broad range of special fasteners made to customer specification.

The capacity and versatility of Alcoa's headers, threaders, slotters, screw machines and related secondary equipment permit Alcoa to provide industry with thousands of standard and special fasteners made from aluminum alloys.

Alcoa's 63 years of aluminum experience can be counted on to provide the best obtainable products of this type. Engineering and design assistance are readily obtainable for analysis of your parts to determine where costs can be lowered and quality improved. Special tools and gauges are built in Alcoa's own toolrooms to facilitate production and inspection. And there is capacity in Alcoa's plants for reasonable delivery schedules to manufacturers with authorized production schedules and metal allotments.

ALCOA ALUMINUM ®

ALUMINUM COMPANY OF AMERICA • 1808M GULF BLDG., PITTSBURGH, PA.



The twelve-month project that improved no-shift driving

Have you a similar problem? Submerge two fans in oil, facing each other. Couple one to an automotive engine. As it turns, it drives the oil against the other fan, transmitting power. This fluid coupling principle is the heart of new type automatic transmissions.

One automobile manufacturer set out to improve it to the Nth degree.

Torque converters had been made by machining cast or forged blanks, or by assembling stamped parts. But these engineers wanted better performance. This meant their converters must be stronger, lighter, more intricate. They asked, "Can we do it in aluminum?"

Our Research specialists saw the chance to show the economy of a little-known process called plaster casting. A process in which plaster, instead of sand, is used for cores to provide more intricate and smoother castings—castings that require no machining of the blades. It promised results that might even exceed the auto maker's requirements.

Final design refinements were made. Then we cast the first samples. They came from the molds smooth and clean—perfect in detail.

While the auto manufacturer machined them to finished dimensions, we set up to test them for strength at high speeds. Coating the parts with brittle lacquer, we spun them in our whirlpit up to 10,000 rpm—over twice their normal operating speed. Cracks in the brittle lacquer told us where strains concentrated. Designs were modified. New samples cast. Tests repeated. The final castings are smooth, faithful in detail, exceed every strength requirement.

This manufacturer's requirements of intricate shapes, strength and lightness may differ from yours. But they were met, as yours can be, by a long-range program of research, test and development. Such a long-range program, started now, may place your company in a commanding competitive position in the years ahead.

for such

1

Knowledge and Specialists

IN MANY FIELDS

Aircraft
Architectural Specialties
Automotive
- **Passenger Cars**
- **Trucks and Trailers**
- **Buses**
- **Parts and Accessories**

Bearings
Building Industry
Business Machines
Chemical Equipment
Communications
Corrosion Studies
Diesel Engines
Electrical Conductors
Electrical Equipment
Farm Machinery
Fasteners
Food Equipment
Handling, Packaging and Shipping
Hardware
Heat Exchangers
Home Appliances
Instrumentation
Insulation
Marine Industry
Mining Equipment
Paper Machinery
Petroleum
Pressure Vessels
Printing Machinery
Railroad Equipment
Structural Engineering
Textile Machinery

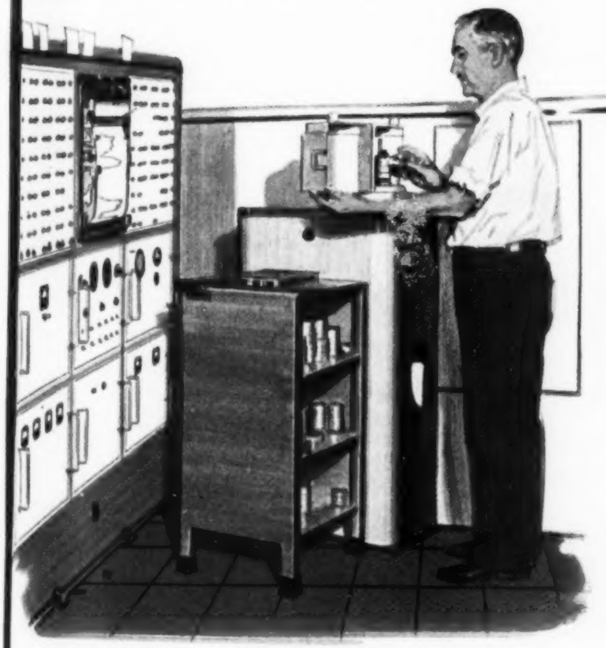
Among these specialists at the Development Division are men already familiar with the problems of your industry. They are your liaison with the Alcoa research, test and fabricating facilities that can be put to work on your problem. Through them the sum total of Alcoa's knowledge will be brought to bear. Knowledge of practical problems of fabrication and costs, gained in thousands of other projects, will flow toward yours.

DEVELOPMENT DIVISION

ALCOA ALUMINUM ®

there are no limitations on *Imagineering*

long-range projects we have these to offer:

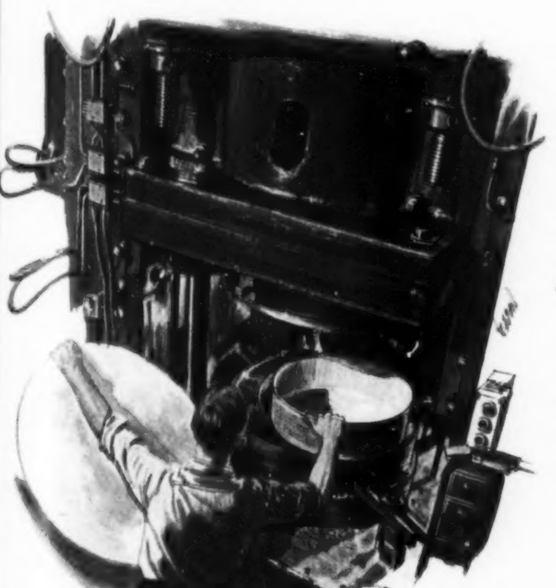


2 FACILITIES FOR BROAD *Research*

A complete chemical analysis of any aluminum alloy in 40 seconds! It's done with Alcoa's Electronic Quantometer. Similar machines are being installed in major Alcoa plants to make sure that the alloy which Research recommends for your job is delivered in the finished part.

3 ADVANCED *Test* EQUIPMENT

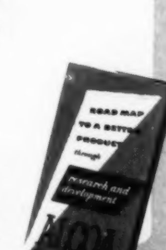
Checking the theories of basic research takes equipment like Alcoa's whirlpit, capable of speeds up to 70,000 rpm. Unforeseen residual stresses and deformation occur when a part is spun at high speeds. Stressing such a part to failure gives a firm foundation of fact on which to base design changes and safety factors.



4 *Process Development Shops* FOR PILOT AND MODEL WORK

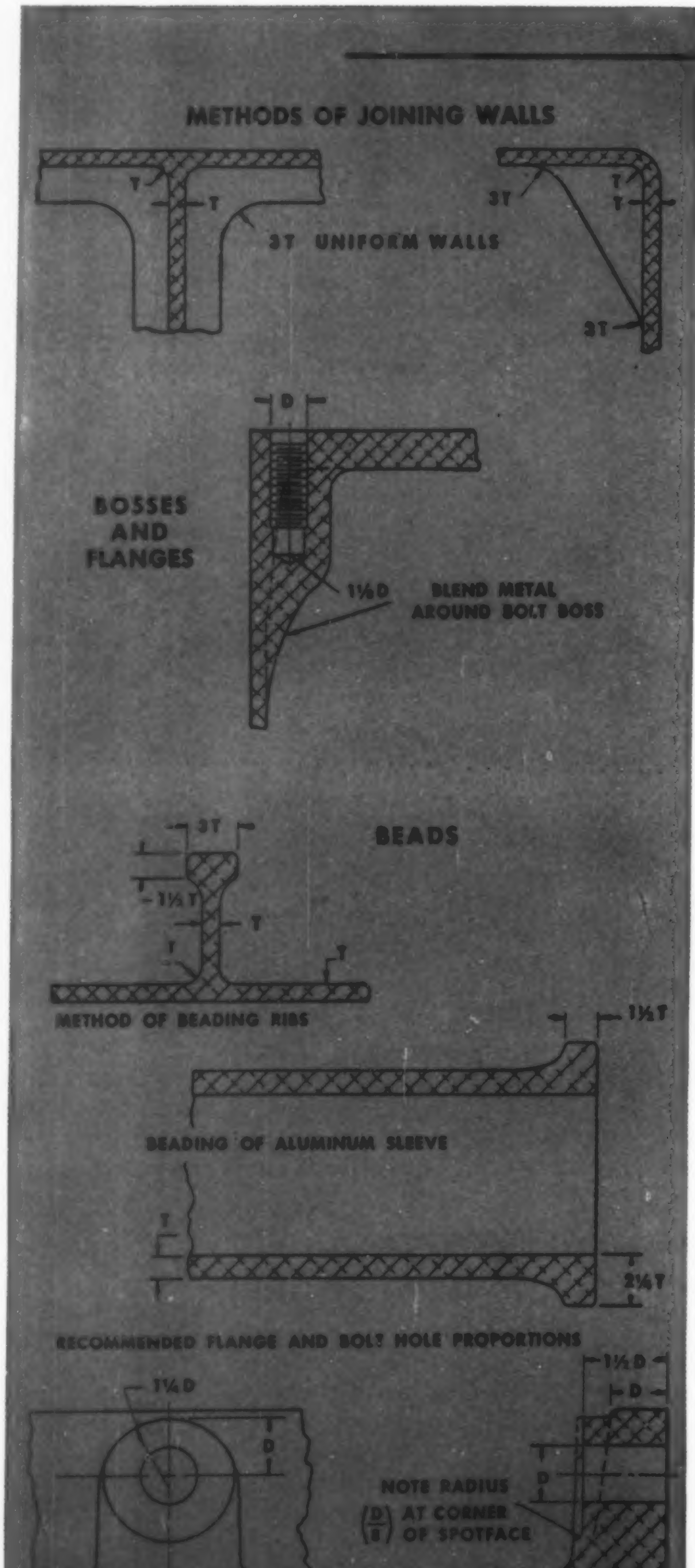
After thorough research and testing, the actual fabrication of your project in aluminum may pose further problems. Here Alcoa makes available all the techniques of welding, forming, machining, casting, heat treating and finishing to create a practical pilot model, then suggests low cost, efficient methods for its fabrication.

For more details . . . on the personnel, research and testing, and shop facilities available at Alcoa, write for your copy of the folder, "Road Map to a Better Product." It is your first step toward putting 63 years of aluminum knowledge to work on a long-term project that may effect a major change in your company's competitive position. Address ALUMINUM COMPANY OF AMERICA, 2185L Gulf Bldg., Pittsburgh 19, Pennsylvania.



ALCOA

Aluminum Castings



Consider . . .

- **Alcoa as a source of supply . . .**
- **Modern foundries strategically located from coast to coast . . .**
- **63 years of light-metal experience.**

Following a few general rules to make sure of stronger, more uniform castings at minimum production cost.

SECTIONS — Try to design sections that are tapered in a way that facilitates flow of metal. If tapered sections are not practical, section thickness should be kept as uniform as possible. When it is necessary to join light and heavy sections, the thinner section should be gradually increased in thickness toward the junction.
Extremely thin sections should be avoided since these require high pouring temperatures resulting in poor metallurgical structure and loss of mechanical strength. Minimum section thickness in sand castings is usually $\frac{3}{16}$ inch; in permanent mold castings, ⅛ inch.

FILLETS — Use generous fillets at all intersections as well as between ribs and bosses and their supporting sections. Fillets adjoining two sections of equal thickness should have a radius at least equal to the thickness. Filleting aids the flow of metal . . . minimizes shrinkage and cracking.

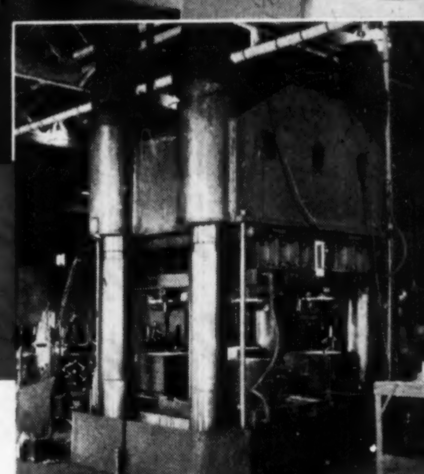
LOCATING POINTS — Plan locating points so they can be used by the foundry and pattern shop for checking dimensions, and by the machine shop in machining. Space these as far apart as the size of the casting permits and, preferably, all on the same side of the parting line so they will not be influenced by shifting of core, cope or drag.

INSERTS — If inserts of other metals are used in aluminum castings, be sure to provide sufficient metal around these inserts to protect the casting against stresses set up by different rates of expansion and shrinkage. Be sure, too, that strong mechanical bonds exist — slots, legs, dogs, and similar projections accomplish this.

PARTING LINES — Keep parting lines as straight as possible. The cost of producing castings with uneven parting lines is usually greater than the cost of redesign to straighten parting lines.

ALCOA

ALUMINUM COMPANY OF AMERICA • 1808M GULF BLDG., PITTSBURGH, PA.



You don't have to Wish for Efficiency

Bearing performance becomes a reality when you use the Norma - Hoffmann "Cartridge" Bearing in your products. This double-row width bearing has 100% greater grease capacity than conventional bearings. The highly efficient seals lock grease in . . . keep dirt out. Carefully factory-packed with Norma-Hoffmann's specially compounded grease assures high antifriction performance for years on end. These are but a few of the reasons why the Norma-Hoffmann "Cartridge" Bearings is *"America's No. 1 Sealed Bearing."*

Norma-Hoffmann

AMERICA'S NO. 1 SEALED BEARING

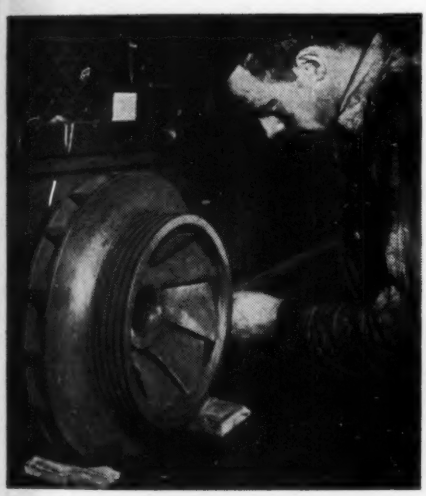
NORMA-HOFFMANN BEARINGS CORP.
Stamford, Connecticut

Field Offices: New York • Chicago • Cleveland • Detroit
Cincinnati • Los Angeles • San Francisco • Dallas • Seattle

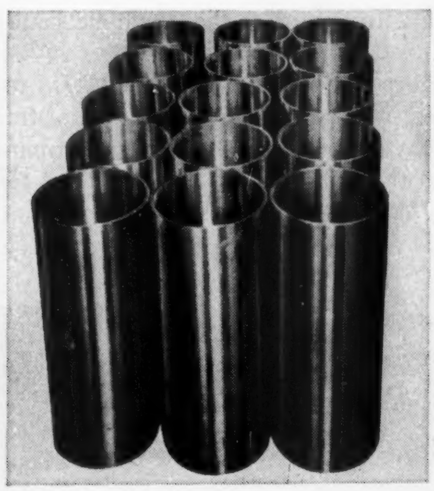
for strong, hard, heat- and corrosion-resisting

Castings

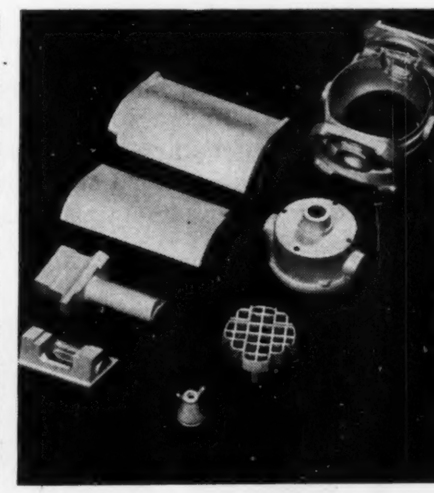
—consider MONEL, NICKEL and INCONEL



SAND CASTINGS



CENTRIFUGAL CASTINGS



PRECISION CASTINGS

If you want castings that must show long life—even under severe corrosive, thermal and mechanical conditions – investigate problem-solving Monel, Nickel and Inconel.

These Inco Nickel Alloys resist corrosion by most acids, alkalies and salts; they have the hardness needed to withstand abrasive and erosive attack; they are strong at high temperatures, at low temperatures.

"S" Monel's high hardness and resistance to galling make it a favorite material for all wearing surfaces where erosion is a factor. "H" Monel is used where better ductility is required on mildly abrasive applications.

Inco will supply the castings to your order from our own foundry at Bayonne, N. J. This foundry is maintained as a service to users of Nickel alloys.

Here, your order gets *double* expert attention. Attention by expert foundrymen; attention by foundrymen who are experts in casting high-Nickel alloys.

At present much of Inco's production is being diverted to defense and you may not be able to get immediate delivery. However, our expert foundrymen are always ready to help you with your special casting problems, whether they be sand, centrifugal or precision.

Pass the details along to Inco at the address below. Let us work it out with you to see how economically it can be solved by use of high-Nickel alloys.

PRECISION CASTINGS ARE PRODUCED IN THESE METALS

Monel®
"H" Monel
"S" Monel
Nickel
Inconel®
Ni-Hard®
Ni-Resist®
Stainless Steels
SAE, AISI, NE Steels
Tool Steels
Copper-Base Alloys
Cobalt-Base Alloys

EMBLEM OF SERVICE
INCO
TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, Inc., 67 Wall Street, New York 5, N. Y.

Think of Inco for Castings in durable metals

Best stop on the road

As many a bus and truck maintenance man will tell you, the best stop on the road is the stop you get with brake blocks made by RAYBESTOS-MANHATTAN. Throughout the automotive industry, in fact, manufacturers and operators agree on the advantages of R/M STOP-AND-GO products . . . brake linings, brake blocks, clutch facings, and engineered automatic transmission parts. That's one big reason why R/M has become the world's largest maker of friction materials.

In many other industries, too, R/M has won outstanding leadership in performance. You'll find R/M friction materials in applications varying from the brake blocks on a drilling rig to the clutch mechanism in a 3-wheeled scooter!

Whatever *your* friction material requirements, call in your R/M representative. He can work from samples, from designs on paper, or from figures on horsepower development combined with desired performance characteristics. Behind him stand the full facilities of four plants, four research organizations, and four testing laboratories.

R/M FIRST IN FRICTION

RAYBESTOS-MANHATTAN, INC.

EQUIPMENT SALES DIVISION • 620 Fisher Bldg., Detroit 2, Mich.

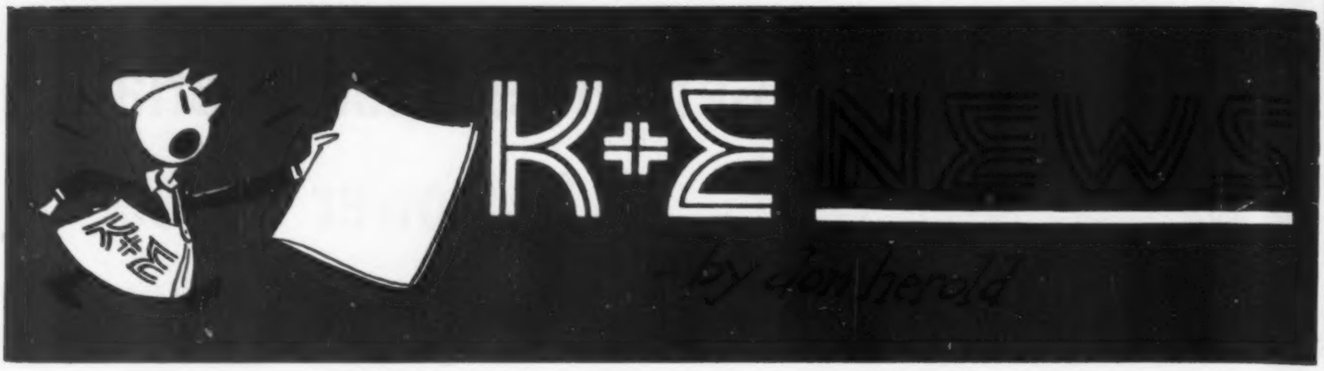
Chicago 11, Ill. Los Angeles 11, Calif. Cleveland 14, Ohio

Factories

BRIDGEPORT, CONN., MANHEIM, PA., PASSAIC, N.J., NO. CHARLESTON, S.C

CANADIAN RAYBESTOS CO. LTD., PETERBORO, ONT.

R/M RAYBESTOS-MANHATTAN, INC., Manufacturers of Brake Linings • Brake Blocks • Clutch Facings • Fan Belts • Radiator Hose • Mechanical Rubber Products • Rubber Covered Equipment • Packings • Asbestos Textiles Powdered Metal Products • Abrasive and Diamond Wheels • Bowling Balls



My hat's off to the people who make K&E products

Take a bow, fellers!

Precision and quality don't grow on trees. But they grow.

At Keuffel & Esser precision and quality are almost a century plant. In other words they have been growing there in fertile soil for exactly 84 years. (K&E was founded in 1867.)

It's mostly a matter of people. Oh, there are machines, too, big ones, little ones—some of them almost human—but it takes people to imagine the machines, and to master them and supplement them.

Precision in the Air

I've been talking about K&E products for a long, long time. Maybe it's time I talked a little about the people behind them.

I've just been through the K&E factory at Hoboken again. I wish you could have been along, because you, as an engineer, would have seen much more than I. But even I could sense the honest craftsmanship and the father-and-son tradition of precision and the zeal for quality in the air.

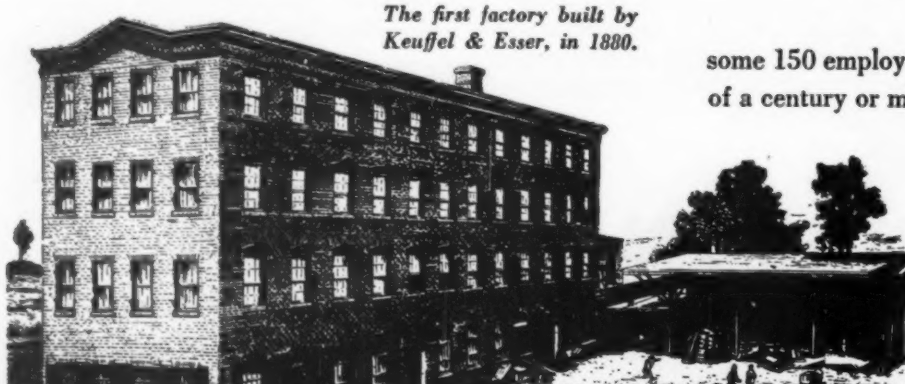
You just don't get to be that fine in one generation.

There are a number of K&E employees who have been around for about a half a century, and there are some 150 employees who have been there for a quarter of a century or more. This latter bunch of kids, as well as the young sprouts who have been there only 20 or 15 years, have inherited the K&E feeling for doing things the good, old, exciting, honest way.

But don't get the idea that there is any moss on K&E. An outfit that has thrived this long has to have the knack of remaining perennially young and of keeping ahead of the pack.

MOST K&E WORKERS MUST HAVE CUT THEIR TEETH ON K&E SLIDE RULES

The first factory built by Keuffel & Esser, in 1880.



COMPARISON PROVES the VALUE of VEELOS

the Adjustable V-Belt...

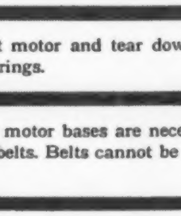
IF you specify v-belt drives for the machines you design you'll be interested in this clear statement of facts about VEELOS, the link v-belt, and endless v-belts.

These 4 reels of Veelos provide up to 316 standard v-belt sizes.

COMPARISON TABLE
VEELOS and ENDLESS V-BELTS

what about...	Veelos V-Belts	Endless V-Belts
ADJUSTABILITY	***Any*** length can be provided for ***any*** v-belt drive due to link construction.	Standard or special lengths must be supplied for ***individual*** drives.
INVENTORY	MINIMUM INVENTORY. 4 reels can care for every v-belt need in the O, A, B and C widths. No deterioration or obsolescence of spare belts.	LARGE INVENTORY. 316 sizes are required to provide a ***complete*** stock in the O, A, B and C widths. Spare belts not immediately used will age and deteriorate.
STOCKROOM STORAGE	SMALL SPACE. It takes less than 2 square feet of wall or floor space to store 4 reels of easily identified Veelos.	LARGE SPACE. Walls and ceilings are often covered with stocks of endless v-belts. Identifying and maintaining full stocks is difficult and costly.
INSTALLATION	Installs quickly ***on any drive*** without resetting motor or tearing down outboard bearings.	Necessary to reset motor and tear down drives with outboard bearings.
MAINTENANCE	Belts can be adjusted or replaced without moving the motor.	Sliding or pivoted motor bases are necessary to replace endless v-belts. Belts cannot be adjusted individually.
OPERATING EFFICIENCY	Full power delivery can be maintained because the tension of each belt in a matched set is kept uniform by removing or adding links.	Individual belts cannot be adjusted to maintain uniform tension and provide full power delivery.
DRIVE LAYOUT	No limitations are imposed by belt length.	Limited by the availability of standard or special belt lengths.

If you would like to learn more about Veelos—how it can save you money and keep your machines producing—write today for your copy of the Veelos Data Book. It's free and full of facts!



VEELOS THE LINK V-BELT

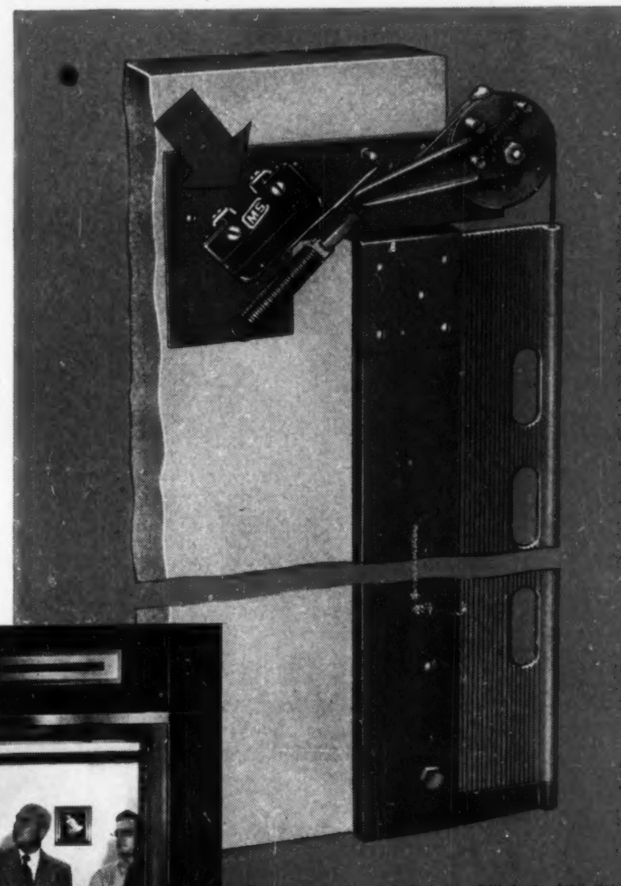
MANHEIM MANUFACTURING & BELTING COMPANY
MANHEIM, PENNSYLVANIA

...ADJUSTABLE TO ANY LENGTH ... ADAPTABLE TO ANY DRIVE

Made in all widths in three types: regular, oil-proof and static conducting. Also double V in A and B. Packaged on reels in 100-foot lengths. Sales engineers in principal cities; over 350 distributors throughout the country. VEELOS is known as VEELINK outside the United States.

can supply a precision switch electrical switching requirement

Richards-Wilcox Engineers find a MICRO Precision Switch is "good design" in elevator safety door edge.



Among the many diversified products of Richards-Wilcox Mfg. Co., world's largest manufacturers of door hangers and tracks, is a safety door edge for passenger elevators.

This device is designed to prevent a person or object from being caught between door and jamb while the cab doors are closing.

Essentially, the safety door edge consists of a molded rubber edge which encases a steel cable. This cable extends along the door's entire height, over a cable sheave, and thence to a spring which holds the cable taut.

Pressure against the cable, as by a person not entirely clear of the elevator doors, actuates a MICRO precision switch. This instantly reverses the door movement, permitting safe passage to or from the cab.

Richards-Wilcox engineers selected a MICRO precision switch for this application because of its small size, to fit into limited space; extreme sensitivity; capacity for long-lived dependability; and plenty of overtravel without harm to equipment.

Illustrated is the use by Richards-Wilcox of the small, precise Type "W" leaf-actuated MICRO precision switch. Located at the top of the door, the switch is actuated by the dog on the sheave pulley when door cable is tightened by pressure against the door edge.

MICRO MS SWITCH

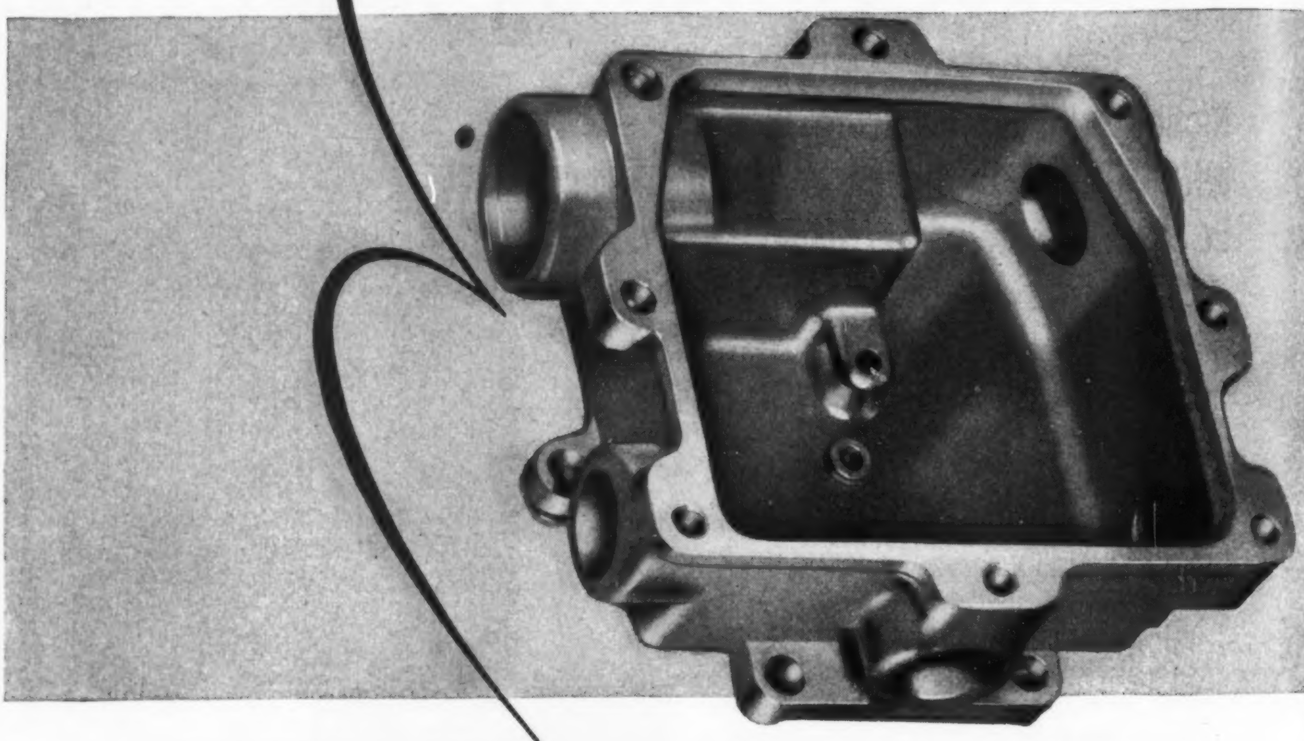
FREEPORT, ILLINOIS

MICRO Snap-Action Switches . . . Honeywell Mercury Switches

H HONEYWELL

MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

Flexible DESIGN POTENTIALS



with MADISON-KIPP *Zinc and Aluminum* DIE CASTINGS

Space limitations, usage and other reasons may dictate a complicated part like the precision airplane switch housing illustrated. There are cored holes and bosses on six sides plus an interlocking core. The Madison-Kipp die casting process is ideal for producing these "special" shapes and offers the designer great flexibility within a reasonable cost budget. Please send all inquiries to our home office in Madison, Wisconsin.

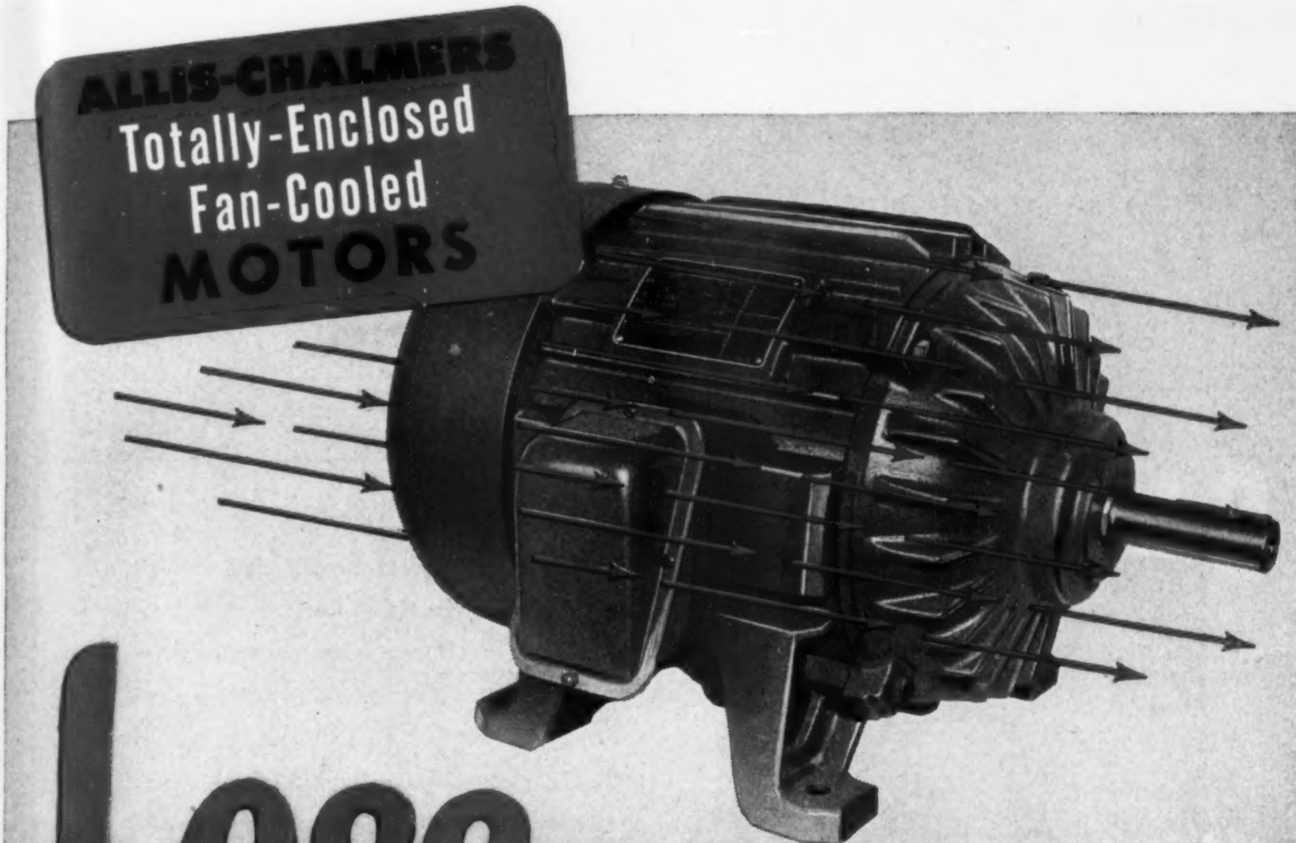
MADISON-KIPP CORPORATION

210 WAUBESA STREET, MADISON 10, WIS., U.S.A.

ANCIENS ATELIERS GASQUY, 31 Rue du Marais, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS



Less MOTOR CLEANING ...INSPECTION...OVERHAUL!

HERE'S A MOTOR that actually blows itself clean! Dirt is carried away by cooling air blown over the ribbed cast iron frame and bearing housings of this new Allis-Chalmers tefc motor.

Dirt can't build up to cause overheating. Concealed air passages and pockets have been eliminated. Even oily dirt that sticks can simply be wiped or blown off.

And this means savings! Maintenance costs are traditionally low on totally-enclosed, fan-cooled motors. But they're lower than ever before on the new Allis-Chalmers Type APZ tefc motor.

Rigid Construction

The frame is cast iron which has high resistance against corrosion and distortion. Bearings are pre-lubricated at the factory and should need no attention for years. Tapped holes with pipe plugs to permit regreasing and to provide grease relief are standard equipment.

Get All The Facts

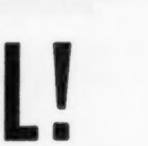
The new Allis-Chalmers Type APZ totally-enclosed, fan-cooled motor is built in all NEMA standard frame sizes from 224* to 505. Also in explosion-proof type. Your A-C Authorized Distributor or District Office has complete information. Call today, or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for Bulletin 51B7225.

A-3426

Sold . . . Applied . . . Serviced . . .

by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.



TEXROPE — Belts in all sizes and sections, standard and *Vari-Pitch* sheaves, speed changers.

PUMPS — integral motor and coupled types from ¾ in. to 72 in. discharge and up.

Texrope and Vari-Pitch are Allis-Chalmers trademarks.

ALLIS-CHALMERS

*Similar design non-ventilated motors Type APK, also available in frames 203 to 224 inclusive.

By an ingenious method devised by Houghton engineers, durable leather is thoroughly impregnated with tough, "springy" synthetic rubber.

Although limited in supply at present, due to allocations of raw materials, this new development is definitely the packing of tomorrow, combining the outstanding benefits of both leather and rubber.

Advantages LEATHER Offers:

- Low coefficient of friction
- Longer life
- High resistance to abrasion, extrusion and cold vulcanizing

Benefits RUBBER Provides:

- Perfect Seal
- Resistance to heat, oils, solvents
- Exceptional pliability
- Ease of installation

Houghton VIM #1243 Leather Packings—already in use for several years—are performance-proved! They are supplied in "V" and Cup Types, on rated orders, in standard sizes only. For full details, write E. F. Houghton & Co., Philadelphia 33, Pa.

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E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

handle more shapes—sizes and materials on one machine!

—give the machines you build extra "Change-over Capacity"—extra *profit* capacity with—

REEVES

VARIABLE-SPEED DRIVES

With so many plants now converting to defense production, your customers are in critical need of machines that can handle the greatest possible variety of work without costly delays in changing over from one job to another.

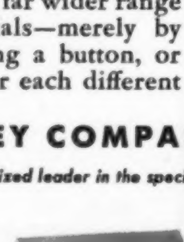
By making REEVES Variable-Speed Drives standard equipment, you can give your customers machines that handle a far wider range of shapes, sizes, and materials—merely by turning a handwheel, touching a button, or automatically. And, *always,* for each different shape, size or material, the REEVES Drive will deliver *exactly* the right speed to assure the maximum rate of production.

Take the first step today in this vital improvement of your product. Write for the name of the REEVES Speed Control Engineer in your locality. He'll give you full details on *America's only complete line of variable speed drives . . .* the reliable REEVES line . . . competent counsel on how to adapt REEVES to your particular needs. No obligation, of course.

REEVES PULLEY COMPANY · COLUMBUS, INDIANA

Recognized leader in the specialized field of variable speed control

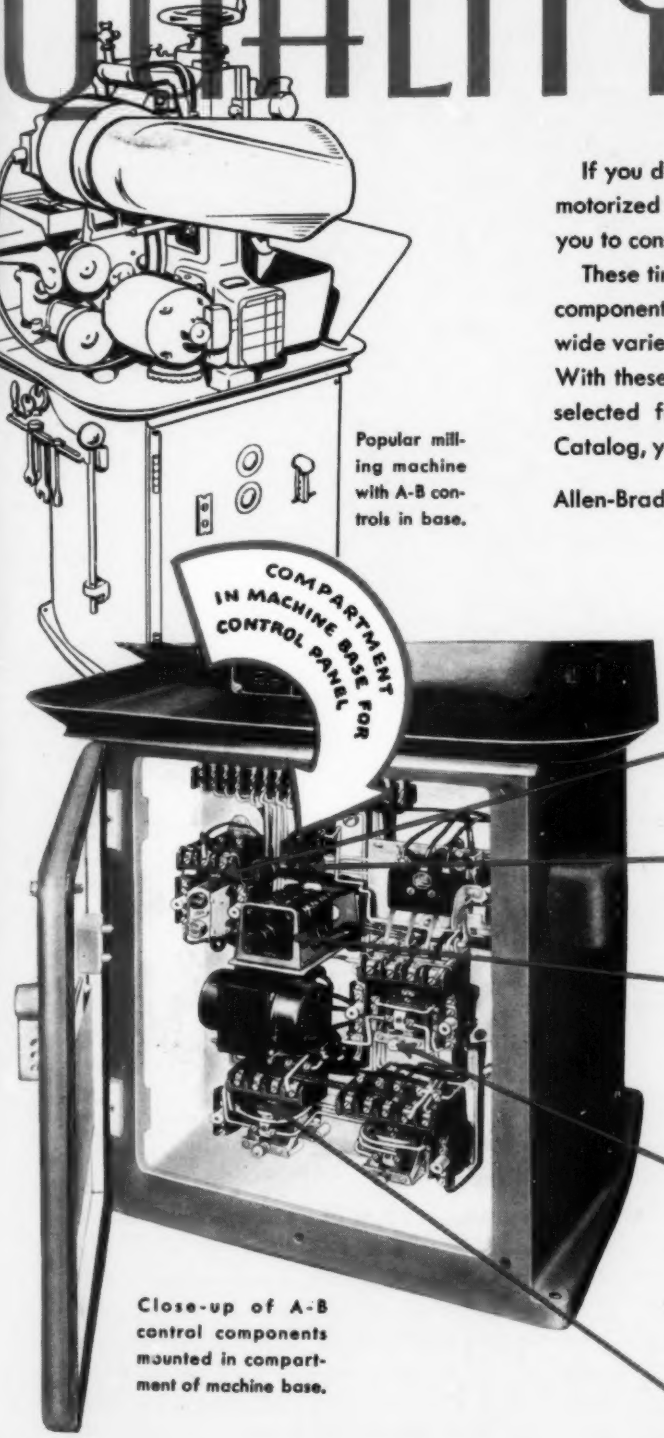
Ask for complete information, including engineering drawings and technical data, on the full line of REEVES Variable-Speed Drives and Controls. Send for Catalog No. H75-3N.



accurate · variable

REEVES *Speed Control*

QUALITY CONTROL COMPONENTS



Popular milling machine with A-B controls in base.

Close-up of A-B control components mounted in compartment of machine base.

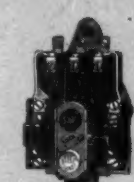
If you design or manufacture motorized machinery, it will pay you to consider A-B controls.

These time-tested A-B control components are available in a wide variety of types and sizes. With these components, quickly selected from the A-B Handy Catalog, you can assemble control panels to provide the exact control sequence needed for maximum output.

If you have a new machine on your drawing boards, why not call in an Allen-Bradley control engineer. His advice may simplify your control design and improve your machine operation.

Allen-Bradley Controls are a Sales Asset to any Machine Tool

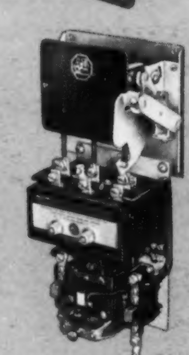
MANUAL STARTERS
Bulletin 609 Manual Starters have quick make, quick break contacts and overload relays. In a variety of enclosures.



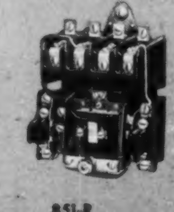
SELECTOR SWITCHES
Selector switches and oiltight push buttons.

DRUM SWITCHES
Drum Switches for pilot control service, reversing operation, and multi-speed motor control. Furnished in enclosures.

COMBINATION STARTERS WITH DISCONNECT UNITS
These Bulletin 712 Combination Starters have a manually operated disconnect unit and a magnetic starter switch with overload relays on a single mounting plate. Can also be furnished with circuit breaker.



MAGNETIC SWITCH
The A-B line of Bulletin 709 Solenoid Starters are available in 7 sizes, 1 to 300 hp, 220 v; 600 hp, 440-550 v. All have double break, silver alloy contacts and overload relays.



851-R

Follow the example of leading machine tool manufacturers by adding A-B controls as a sales asset to your motorized machines. Catalog will be gladly sent to you on request.
Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wisconsin

ALLEN-BRADLEY
QUALITY
MOTOR CONTROL

A-B Quality

Need a current-carrying material which is harder than copper, with greater resistance to wear? Investigate Berylco beryllium copper.

Berylco 10 has a conductivity of 45% and a tensile strength as high as 130,000 psi. It also has high elastic, endurance and impact strength... good corrosion resistance... ability to withstand high temperatures. It has been widely used in circuit breakers, switch gear, and other current-carrying parts. It is available as strip, rod, bar, wire and forgings.

Berylco 50 has even greater conductivity than Berylco 10. It exceeds the requirements of RWMA Class 3 resistance welding alloys. Its hardness and conductivity make it ideal for spot, seam, flash and projection welding dies and electrodes. It is available as rod and bar stock, and as seam welding wheels.

Strength, conductivity, resistance to wear are only a few of the superior properties of Berylco beryllium copper. Find out what Berylco can do for you... take advantage of the technical knowledge of the world's largest producer.

Tomorrow's products are planned today — with Berylco beryllium copper

SAMPLE MATERIAL AVAILABLE FOR TESTING PURPOSES

BERYLCO THE **BERYLLIUM** CORPORATION

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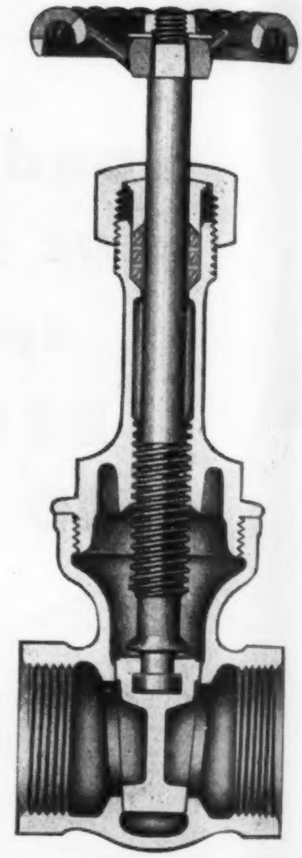
Key to better piping design . . . your easy-to-use CRANE Catalog

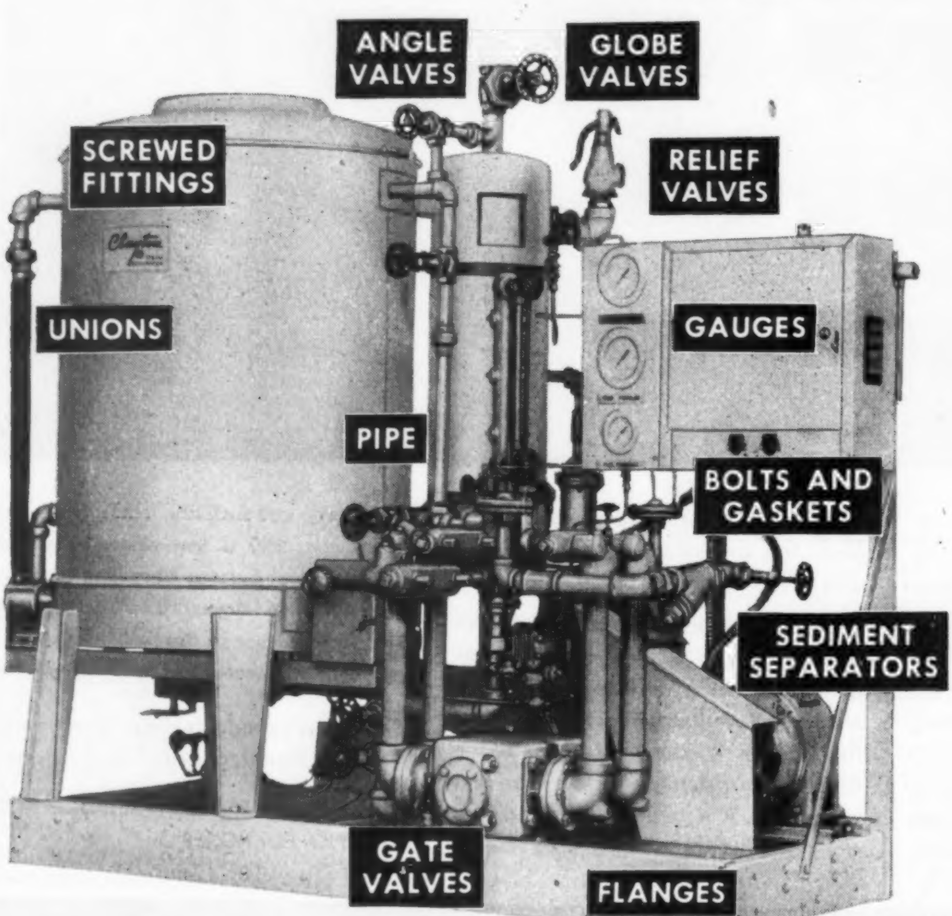


You can design better piping into any product . . . faster . . . when you specify from your Crane Catalog. Here, between two covers, you'll find the world's most complete assortment of quality piping materials—carefully arranged for convenient selection. And for every piping item there's a full listing of recommended services; complete design, material, and construction details; plus helpful, easy-to-use pressure and temperature rating tables. In addition, your Crane Catalog answers general engineering questions connected with designing efficient piping systems.

Specifying Crane gives your product added value, too. Now that replacements are harder to get, your customers realize more than ever the advantages of dependable, longer-lasting Crane Quality equipment on the machinery they buy.

FOR RUGGED, DEPENDABLE service on steam, water, oil and gas lines—Crane recommends 150-Pound Brass Gate Valves with accurately guided solid wedge disc. Tight stem seal assured by high quality stuffing box packing and gland; can be repacked under pressure. Rising or Non-Rising Stem; screwed or flanged ends. Sizes: ¼ to 3-inch. See your No. 49 Crane Catalog, page 17.

FOR A BIGGER SELECTION OF BETTER PIPING ... CHECK THE BROAD CRANE LINE



Steam Generator by Clayton Manufacturing Company, El Monte, California

CRANE CO.

General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

Can You Use the "Utiliscope"?

The advertisement at the right appeared in BUSINESS WEEK. It has been suggested that this ad contains considerable food for thought for the readers of MACHINE DESIGN also. The particular application illustrated here may not interest you but it probably will suggest other uses for the "Utiliscope" in your operations.

If you want to look into the possibilities of the "Utiliscope", simply write us for a copy of Bulletin 1025K which explains the equipment and shows various applications. Please address your request to Department "K".

DIAMOND POWER SPECIALTY CORPORATION

Department "K", Lancaster, O.

ELECTRUNITE TUBING

Eases Life-

FOR THE MANUFACTURER...

FOR THE PATIENT...

HOSPITAL PATIENTS can relax in every position, from full-reclining to upright, in this sturdy rejuvenating chair made by Barcalo Manufacturing Company. Steel tubing provides the stiffness and rigidity to make the chair steady and reassuring to the patient, yet light to move.

The manufacturer likes the way ELECTRUNITE Steel Tubing works on this application. Uniform ductility and wall thickness assure rapid, predictable forming and bending of the tubes to shape. Where tube ends must be fully flattened at joints, there's no trouble with cracks and fractures. The excellent surface of this ELECTRUNITE Tubing requires no special handling or trick treatments to hold long-lasting finishes under severe service.

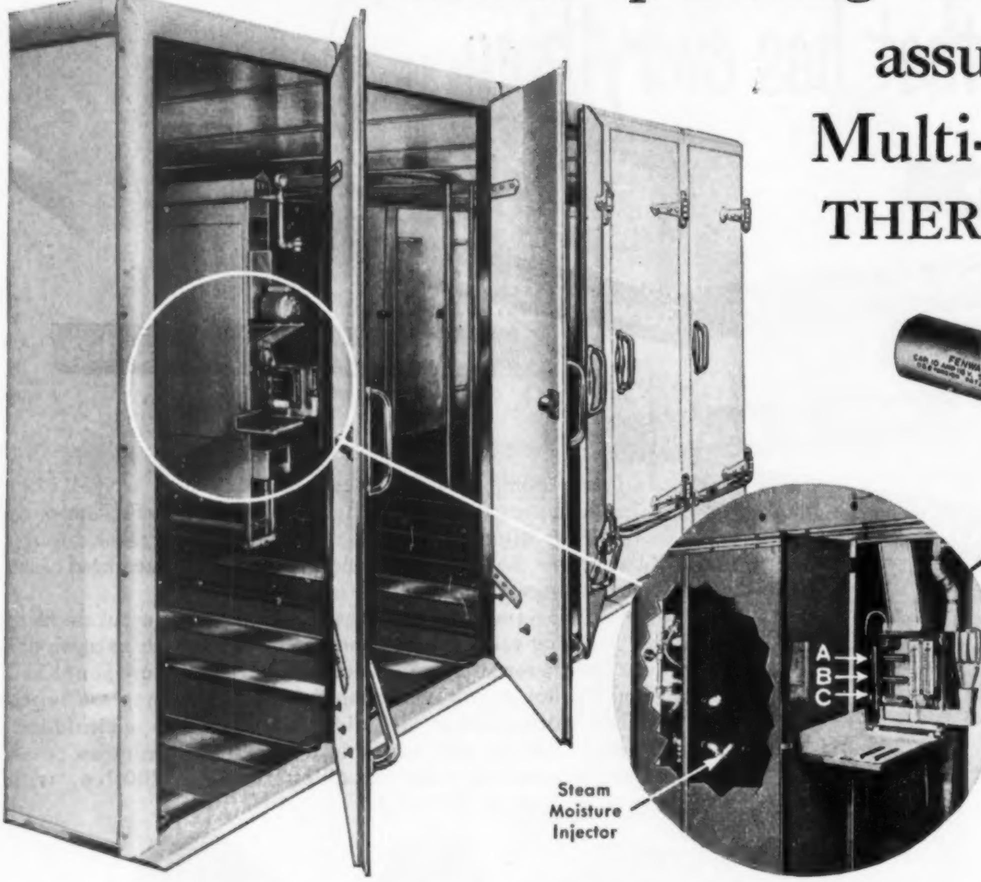
Have you considered using ELECTRUNITE Steel Tubing in your essential products, such as these invalid chairs? We'll be glad to discuss your problems . . . and offer you the benefits of Republic's 3-Dimension Metallurgical Service. It's the helpful service that focuses the knowledge and experience of field, mill, and laboratory metallurgists on your fabrication problems.

REPUBLIC STEEL CORPORATION
STEEL & TUBES DIVISION
224 EAST 131st STREET
CLEVELAND 8, OHIO

Republic

ELECTRUNITE TUBING

Uniform "proofing" for bakeries assured by Multi-Purpose THERMOSTAT



3 THERMOSWITCH thermostats control air in Anets Rack "Proof" Box. Thermostat (a) controls air temperature, thermostat (c) with wick acts as humidity control, and thermostat (b), set at 75 F, is wired in series with thermostat (c) to prevent moisture injection with resultant condensation and flooding when starting cold box.

Proper control of the "proof" box is a very important factor in commercial baking. These boxes "proof," or raise, yeast-type doughs by means of warm, humid air that is kept at a pre-determined temperature and humidity. This air must not only be held consistently to requirements, but must also be controlled in such a way that condensation is prevented when box is turned on.

To accomplish this, Anetsberger Brothers, makers of Anets proof boxes, chose Fenwal THERMOSWITCH thermostats. In successful operation on these boxes for more than ten years, these thermostats maintain conditioned air with laboratory accuracy. Operating on 24 volts A.C., they regulate temperature and humidity of air with such precision that bakeries can depend on uniform "proofing."

Low cost, compact, precise THERMOSWITCH thermostats solve many types of control problems. Easy to install, easy to maintain, they operate on a unique principle that permits effective control of many variables where heat is a factor. Their activating control element is the single-metal shell that expands or contracts instantaneously with temperature changes, making or breaking the totally enclosed electrical contacts.

Find out now how Fenwal THERMOSWITCH units can help you. Mail coupon today.

Fenwal

THERMOSWITCH®

The Precision, Multi-Purpose, Thermostat Control

SENSITIVE . . . *but only to heat*

FREE! **Get this bulletin . . . see what Fenwal THERMOSWITCH Units can do for you.**
Just fill in coupon and mail . . . no obligation.

FENWAL, INCORPORATED, 1912 Pleasant St., Ashland, Mass
Los Angeles, Cal.

TEMPERATURE CONTROL ENGINEERS

Name..Position............................
Company..
Street...
City.....................................Zone..........State.......................

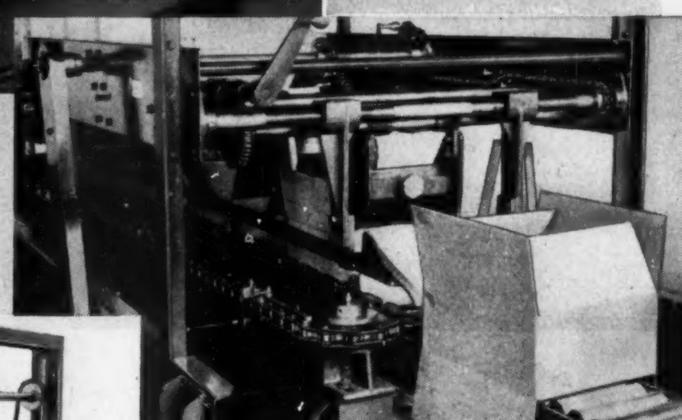
I am chiefly interested in the applications checked:

- ☐ Heating
- ☐ Cooling
- ☐ Humidity Control or Detection
- ☐ Alarm (over-temperature, under-temperature)
- ☐ Vapor Control
- ☐ Timing (thermal)
- ☐ Radiant Heat Control
- ☐ Pressure Control (by controlling vapor temperature)

OTHER (Please fill in your special requirements)........
....
....

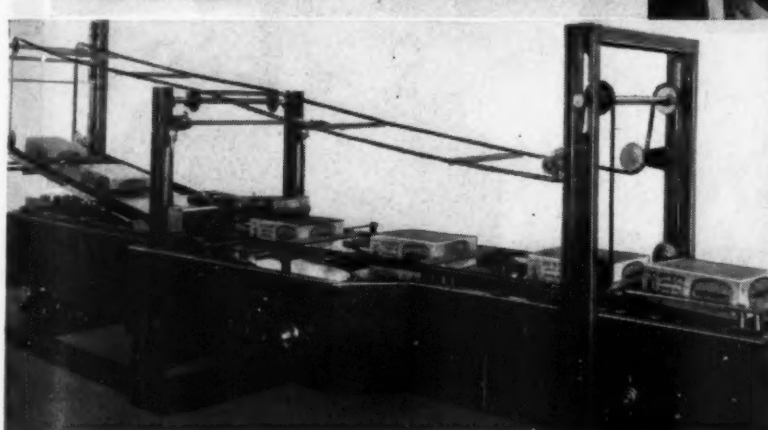
SIMPLE AS A-B-C

Automatic Top and Bottom Case Sealer made by A-B-C Packaging Machine Corp., Quincy, Ill. Main drive Diamond No. 434, No. 66 on sealing operation and 1½"P extended pitch chain for conveying the cartons through gluer section.



Diamond No. 434 roller chain for main drive and No. 66 with cross flight attachments for conveying on A-B-C Case Unloader and Unscrambler.

A-B-C Semi-Automatic Top and Bottom Case Sealer with Diamond No. 434 on main drive, No. 66 on closing mechanism and 2"P roller conveyor chain for conveying cartons through gluer section.



DIAMOND
ROLLER CHAINS
Simplify Operation

● For the packaging of products of all kinds for civilian or military use, modern automatic machinery is necessary because it multiplies the speed and requires a minimum of manual labor.

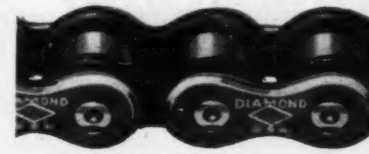
Driven by dependable Diamond Roller Chains, the A-B-C Case Sealers and Unloaders operate at high speed and low cost. Efficient steady operation is assured with minimum labor or attention.

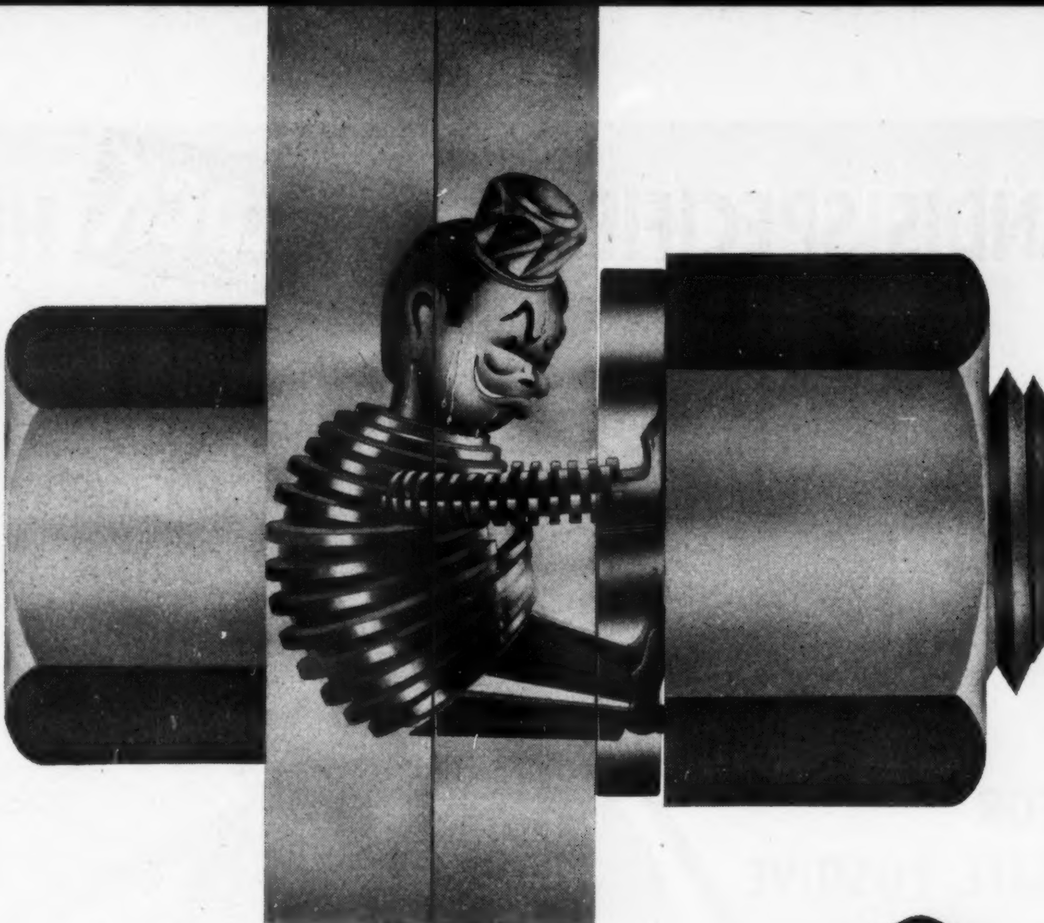
Whatever the particular requirement, short or long centers, fast or slow speeds, unusual strain or shock—wherever transfer of power or material without waste or slip is important—DIAMOND ROLLER CHAINS perform with time and cost saving advantages.

DIAMOND CHAIN COMPANY, Inc.
Dept. 435, 402 Kentucky Ave., Indianapolis 7, Indiana
Offices and Distributors in All Principal Cities

DIAMOND

ROLLER CHAINS





LANDIS SPECIFIES SNAP-LOCK HERE

TRADE MARK

FOR SAFE, POSITIVE POSITIONING HERE

Electric traverse for the wheel base of this Landis Grinder is an exacting function. The critical control of over-travel depends upon positive, accurate action of the limit switch, to prevent damage to the machine.

No wonder they picked Snap-Lock! It's the choice of over 80% of the nation's machine tool builders, proved in use for dependability under the extremes of heavy-duty service. Here are the exclusive design and construction features that have contributed to this outstanding acceptance record:

1. SNAP make and break (fast acting—accurate)

2. Pure silver self-wiping contacts (no arcing)

3. Positive on or off locking (can't stop on dead center)

4. Separate sealed electrical and mechanical sides (for added safety)

5. Hardened steel moving parts (for greater strength, longer life)

Snap-Lock Limit Switches are built in a variety of types and sizes to suit every industrial application; special mountings are available. May we show you how they can be designed into your product?

The complete range of Namco standard Snap-Lock Limit Switches is illustrated and tabulated in Bulletin EM-50.

ELECTRICAL MANUFACTURING DIVISION

The NATIONAL ACME CO.

180 EAST 131st STREET • CLEVELAND 8, OHIO

Acme-Gridley Bar and Chucking Automatics: 1-4-6 and 8 Spindle • Hydraulic Thread Rolling Machines • Automatic Threading Dies and Taps • The Chronolog • Limit, Motor Starter and Control Station Switches • Solenoids Centrifuges • Contract Manufacturing

THEY'RE GOOD, CLEAN, SOLID STEEL

Yes, all the way through, from outer rim to hub, these Bethlehem blanks are good, clean, solid metal—solid steel.

Frankly, we go all out to make them strong. Starting with choice steel from selected heats, we forge and roll the blanks in a single operation. This unique process combines, in the finished piece, the strength of a forged part and the smoothly-flowing grain of a rolled one. As a result, thinner sections are often possible, so that considerable savings in weight can be made.

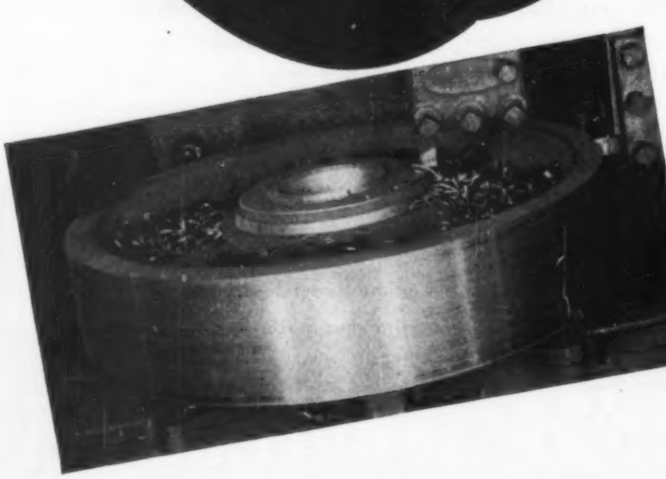
Another advantage: the blanks are so easy to machine. No matter where you cut—no matter how deep—you're always cutting in firm, homogeneous metal of uniform density. There's no danger of running into flaws after expensive preliminary cuts have been taken.

Bethlehem blanks are especially good for heavy-duty applications, such as gears, crane and sheave wheels, turbine rotors, flywheels, tire molds, etc. Sizes range from approximately 10 in. to 42 in. OD, with heat-treating optional. Write for Booklet 216; it contains many pictures and will give you scores of details that we haven't room for here.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

BETHLEHEM STEEL

On the Pacific Coast Bethlehem Products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation



BETHLEHEM ROLLED-AND-FORGED CIRCULAR PRODUCTS


SELF-LUBRICATED FOR Normal LIFE
Lubriflush
FOR Longest LIFE
U.S. MOTORS
(See next page)

We are leading a double life!

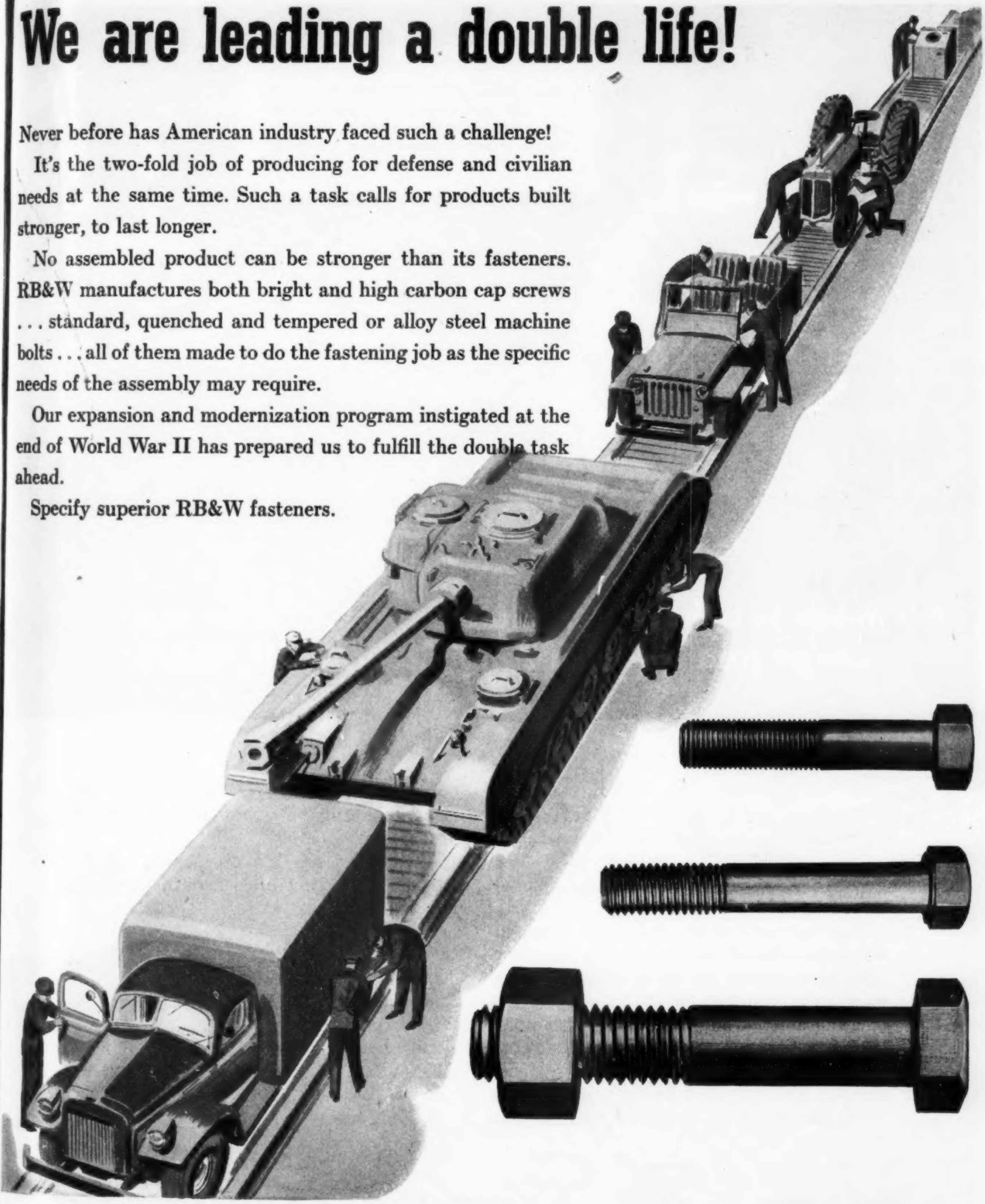
Never before has American industry faced such a challenge!

It's the two-fold job of producing for defense and civilian needs at the same time. Such a task calls for products built stronger, to last longer.

No assembled product can be stronger than its fasteners. RB&W manufactures both bright and high carbon cap screws . . . standard, quenched and tempered or alloy steel machine bolts . . . all of them made to do the fastening job as the specific needs of the assembly may require.

Our expansion and modernization program instigated at the end of World War II has prepared us to fulfill the double task ahead.

Specify superior RB&W fasteners.



RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

RB&W
THE COMPLETE QUALITY LINE

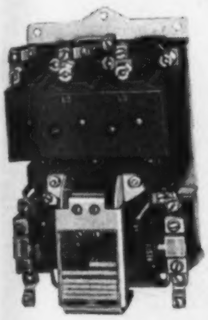
Plants at: Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at: Philadelphia, Detroit, Chicago, Dallas, Oakland. Sales agents at: Portland, Seattle.

106 YEARS MAKING STRONG THE THINGS THAT MAKE AMERICA STRONG

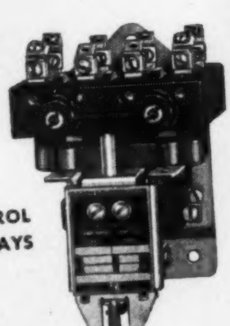

Exact precision alignment is secured with sleeve bearings more readily than with any other type. Bunting Cast Bronze Bearings pressed into the housing and bored in line assure the utmost in precision alignment. When alignment is one of your problems utilize this outstanding advantage and consult the Bunting Engineers whose experience is at your disposal. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Branches in Principal Cities.
BUSHINGS
PRECISION BRONZE BARS
BRONZE BEARINGS
Bunting®

MACHINE TOOL CONTROL

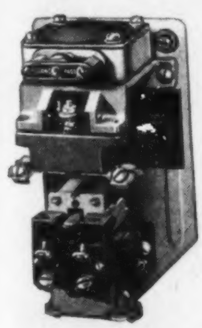
extends SQUARE D's Line of Control Devices designed specifically for Machinery Applications



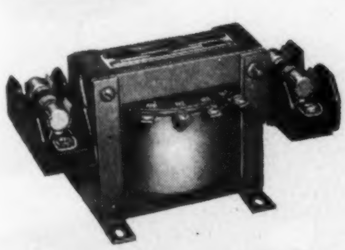
MAGNETIC STARTERS



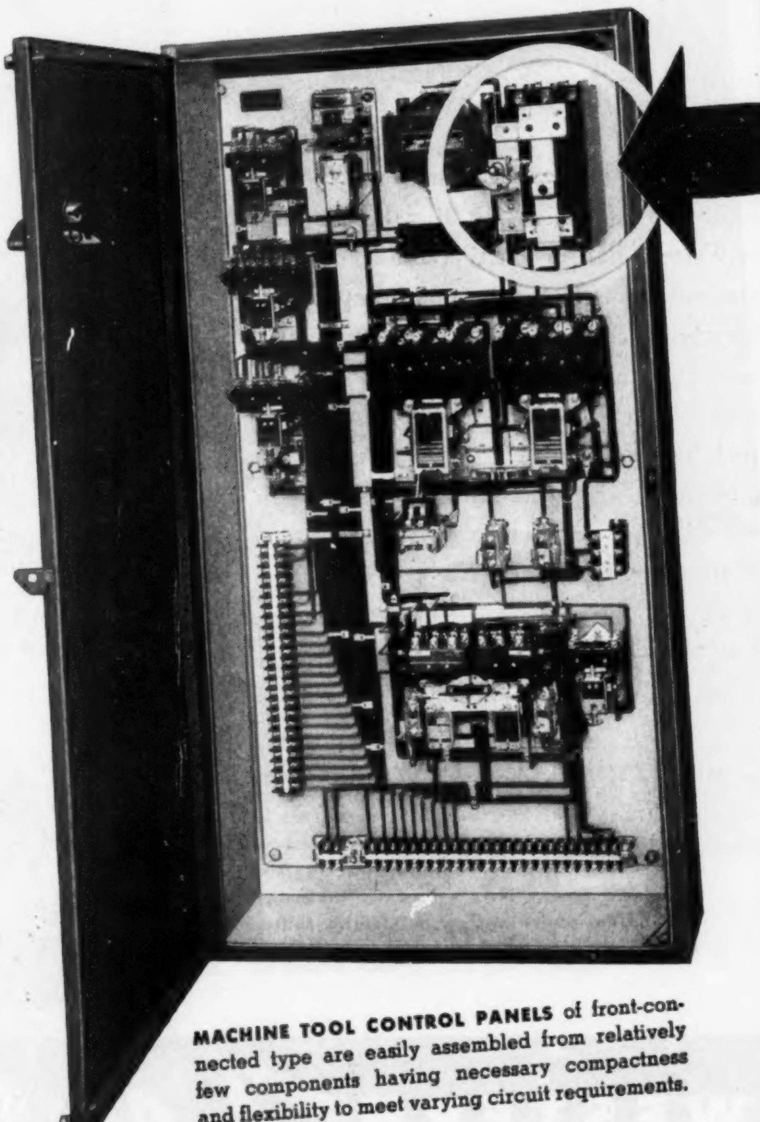
CONTROL RELAYS



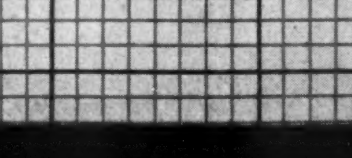
PNEUMATIC TIMERS



CONTROL CIRCUIT TRANSFORMERS



MACHINE TOOL CONTROL PANELS of front-connected type are easily assembled from relatively few components having necessary compactness and flexibility to meet varying circuit requirements.



Watch for Square D's Display Coach—Now on Tour

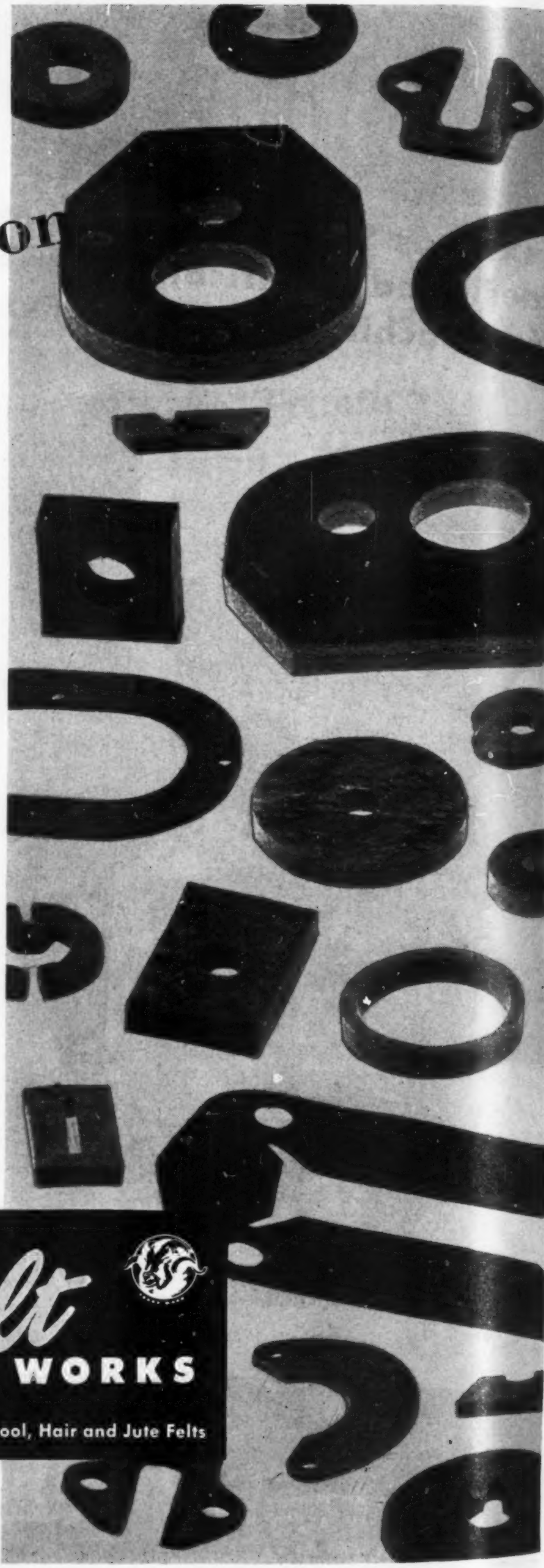
for top precision

Production to close tolerances mostly applies to metal working. But the technique of Western Felt production and processing has built an enviable reputation for engineering precision.

Chemical specifications must be perfectly met — parts from wool softness to rock hardness are cut to close tolerances. As an extremely versatile material Western Felts are resilient, flexible, compressible. They resist oil, water, heat age — do not ravel, fray or lose shape. New uses found daily. It pays to depend on Western Felt.

Check Possible Uses for Your Product

- Excluding dirt, grit, dust
- Retaining lubricants
- Thermostatic insulation
- Isolating vibration
- Cushioning shock
- Padding, packing, seals
- Air and liquid filters
- Gaskets, channels, etc.
- Grinding, polishing, etc.
- Weight reduction
- Instrument mounts



WESTERN Felt WORKS

4035-4117 Ogden Ave., Chicago 23, Illinois

Branch Offices in Principal Cities

Largest Independent Manufacturers and Cutters of Wool, Hair and Jute Felts

Acadia Synthetic Products Division, WESTERN FELT WORKS, Processors of Synthetic Rubbers — Sheets, Extrusions, Molded Parts.

LINK-BELT Ball and Roller Bearings smooth the path of power

By any standard . . . **LINK-BELT Bearing Blocks**

protect and lubricate all moving surfaces

To give you longer bearing life and extended lubricating schedules, Link-Belt Ball and Roller Bearings are Housing-Sealed —all moving surfaces are completely enclosed and centrally lubricated from a large common reservoir. And only from Link-Belt do you get this important advantage on ball as well as roller bearings.

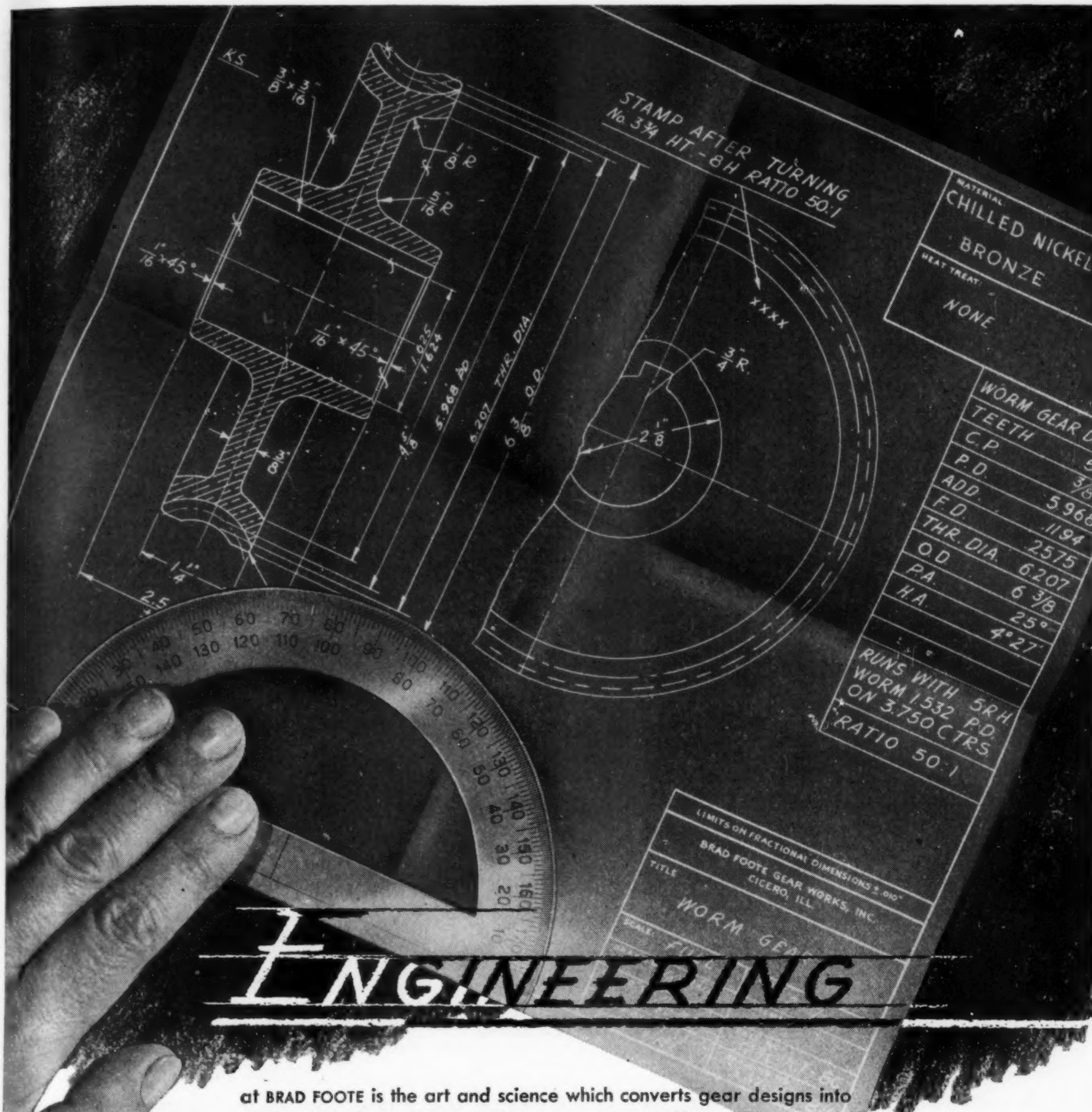
There's a Link-Belt Bearing Specialist near you. Or you can get full engineering information in Data Book 2550.

12,263

LINK-BELT

Ball and Roller Bearings

LINK-BELT COMPANY: Indianapolis 6, Chicago 9, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Springs (South Africa). Offices, Factory Branch Stores and Distributors in principal cities.

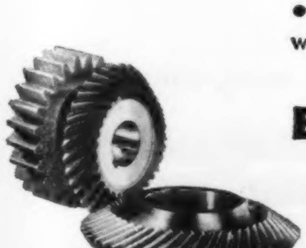


ENGINEERING

at BRAD FOOTE is the art and science which converts gear designs into drawings and specifications of component parts. Here . . . in our own plant . . . our own engineers determine mechanical and metallurgical structures. Our own draftsmen create the intricate, accurate drawings from which other skilled hands make the finished pieces.

• Engineering is important. It is a primary step in BRAD FOOTE's method of complete manufacturing control. It assures you of gears which will perform satisfactorily . . . when used in your shop or on equipment you sell to others.

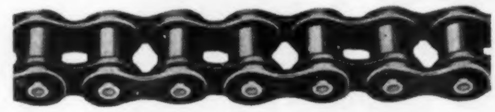
• This engineering service we give our customers is another reason why we can say—*"No one shares our responsibility."*



BRAD FOOTE GEAR WORKS, Inc.

BIshop 2-1070 • OLympic 2-7700 • 1309 South Cicero Avenue
Cicero 50, Illinois

granted?

● In another instance, a Rex Field Sales Engineer persuaded a manufacturer to switch from the pin-and-cotter roller chain he was using to a Baldwin-Rex Riveted Roller Chain.  The change not only resulted in an initial cost saving but in longer life since the rivets have greater holding power.

● To a manufacturer of construction machinery, who had been using cast manganese steel chains, a Rex Field Sales Engineer recommended the use of Rex Steel Chabelco Chains.  Since these chains are designed for efficient operation under dusty, dirty conditions, longer service life for both chains and sprockets at lower overall costs resulted.

Chain Belt COMPANY
OF MILWAUKEE

REX
® BALDWIN-REX

Because Rex Field Sales Engineers have all the resources of a complete chain line at their command, they can recommend without prejudice the exact type or size of chain that will deliver the most efficient performance at the lowest cost to you and your customers. You'll find it will pay you to consult with him regarding your chain application problems. Call or write your Field Sales Office, or mail the coupon.

REX CHAIN & TRANSMISSION DIVISION
Milwaukee 4, Wisconsin

BALDWIN-DUCKWORTH DIVISION
Springfield 2, Massachusetts

CHAIN BELT DISTRICT SALES OFFICES

Atlanta	Dallas	Los Angeles	Pittsburgh
Birmingham	Denver	Louisville	Portland
Boston	Detroit	Midland	St. Louis
Buffalo	Houston	Milwaukee	San Francisco
Chicago	Indianapolis	Minneapolis	Seattle
Cincinnati	Jacksonville	New York	Springfield
Cleveland	Kansas City	Philadelphia	Tulsa

REX STOCK-CARRYING WAREHOUSES

Atlanta	Milwaukee	Seattle
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DISTRIBUTORS THROUGHOUT THE WORLD

[redacted]

Chain Belt Company 51-106
1643 W. Bruce St., Milwaukee 4, Wis.
Gentlemen:
I am particularly interested in..............................
Please send descriptive literature.

Name..............................
Company.............................. *Dept*..............
Address..............................
City.............................. *State*..............

Built-in as an inherent part of the product, Klixon Thermo-Snap Controls give you accurate, dependable temperature control. Actuated by the scientifically calibrated Spencer Disc, they open the circuit with a clean break; close the circuit to a solid make. Their accurate, sensitive operation is best able to withstand shock, vibration, altitude or motion. Small and compact, they are easily adapted to your designs.

Klixon Thermo-Snap Controls are available in many types and ratings including hermetically-sealed units. Military and commercial applications include: use as — low-limit and high-limit controls, fuel delay switches, purge switches, temperature controls, fan switches, tube and rectifier cooling controls in products ranging from tanks and aircraft to radio and electronic equipment and household appliances.

Investigate Klixon Thermo-Snap Controls for your products. Our engineers will gladly help you with your temperature control problems. Write for their help and information, today.

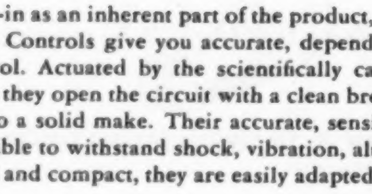
KLIXON

TRADE MARK REG. U. S. PAT. OFF.

SPENCER THERMOSTAT

Division of Metals & Controls Corp.

2512 FOREST ST., ATTLEBORO, MASS.



KLIXON MOTOR PROTECTORS PREVENT MOTOR BURNOUTS

To keep motors operating longer, specify and use motors with built-in Klixon Protectors. Built-in by the motor manufacturers, they prevent motor burnouts by cutting "off" the power should the motor become dangerously overheated. When it cools to safety, the protector snaps the power "on" automatically, if the "automatic reset" is specified . . . or by pushing the red button when the "manual reset" type is used.

SuVeneer Clad Metal's solid copper, copper alloy or nickel cladding is bonded to low-carbon strip steel *for keeps!* It cannot be separated by mechanical means—you can use full freedom in new product design and count on dependable fabrication results. On your future projects—get the special benefits of these solid metals combined with a strip steel base by using *SuVeneer Clad Metal!*

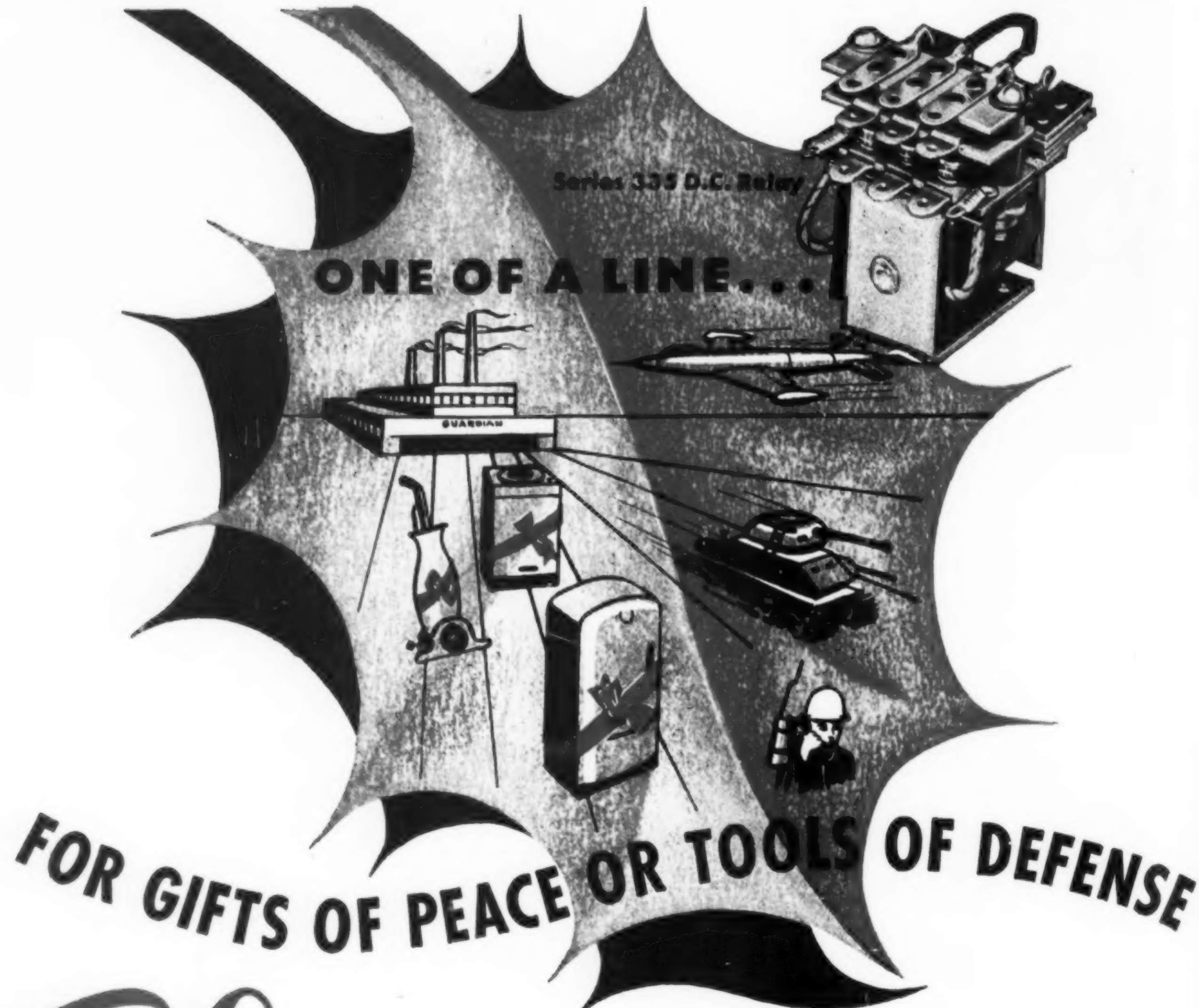
SuVeneer®

CLAD METAL

Superior Steel

CORPORATION

CARNEGIE, PENNSYLVANIA



Relays BY GUARDIAN SERVE ALL FRONTS!

WHETHER FOR PEACE OR DEFENSE a great responsibility is vested in electrical control. In this era of defense there is an urgent demand for electrical controls in *quantity* with the highest degree of *quality* at economical cost. How efficiently Guardian Electric has moved to meet these requirements is convincingly told by the millions of Government Approved Controls by Guardian now being used in planes ... in tanks ... in communications ... in bomb releases ... in radar ... in guided missiles ... in gun controls. The same excellent controls that helped to insure Victory in World War II! If yours is a problem of electrical control requiring relays, steppers, contactors, control assemblies, or the familiar "Guard-A-Seal" *hermetically sealed* relays, consult Guardian. Write.

A.N. CONNECTOR PLUG
HERMETIC SEALED
CONTAINER

AN-3320-1 D. C.

AN-3324-1 D. C.

Series 595 D.C.

Series 610 A.C.—615 D.C.

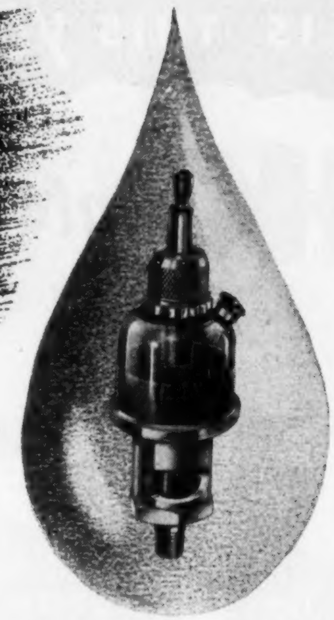
Series 695 D.C.

GUARDIAN (G) ELECTRIC

1601-P W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

For Lubricating Devices Call On GITS First!



GITS Bros. covers the *entire range* of lubricating devices: Oil Hole Covers, Oil Cups, Grease Cups, Bottle Oilers, Gauges. Gravity-Feed, Wick-Feed, Constant Level, Vibrating Rod styles. Threaded or Drive-type. Elbow or Straight.

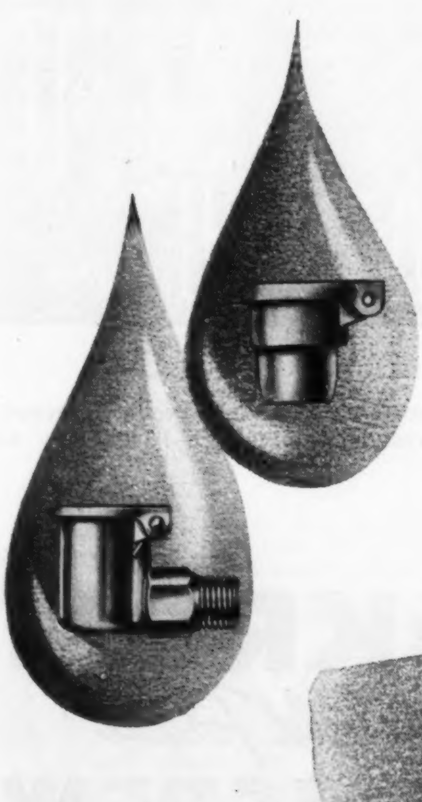
GITS Bros. offers the most complete selection of standard styles.

GITS consistent quality in design, materials and machining has made Gits Lubricating Devices the standard for industry for more than 40 years.

GITS Lubricating Devices are far-famed for solving tough oiling problems at low cost.

GITS Bros. Engineering Staff—true specialists in lubrication engineering—is at your disposal.

Write today for free Catalog No. 60-A. Use it as your handy reference for lubricating devices.



GITS BROS. MFG. CO.

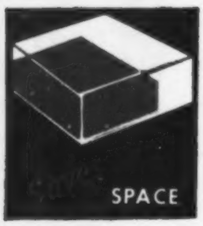
1868 S. KILBOURN AVE. • CHICAGO 23, ILL.

IS THIS *YOUR* FASTENING PROBLEM?

HK *Internal Wrenching solved it!*

The Problem...

To successfully design and maintain in production a complex, machine Punching Die with *standard* "off the shelf" fasteners.

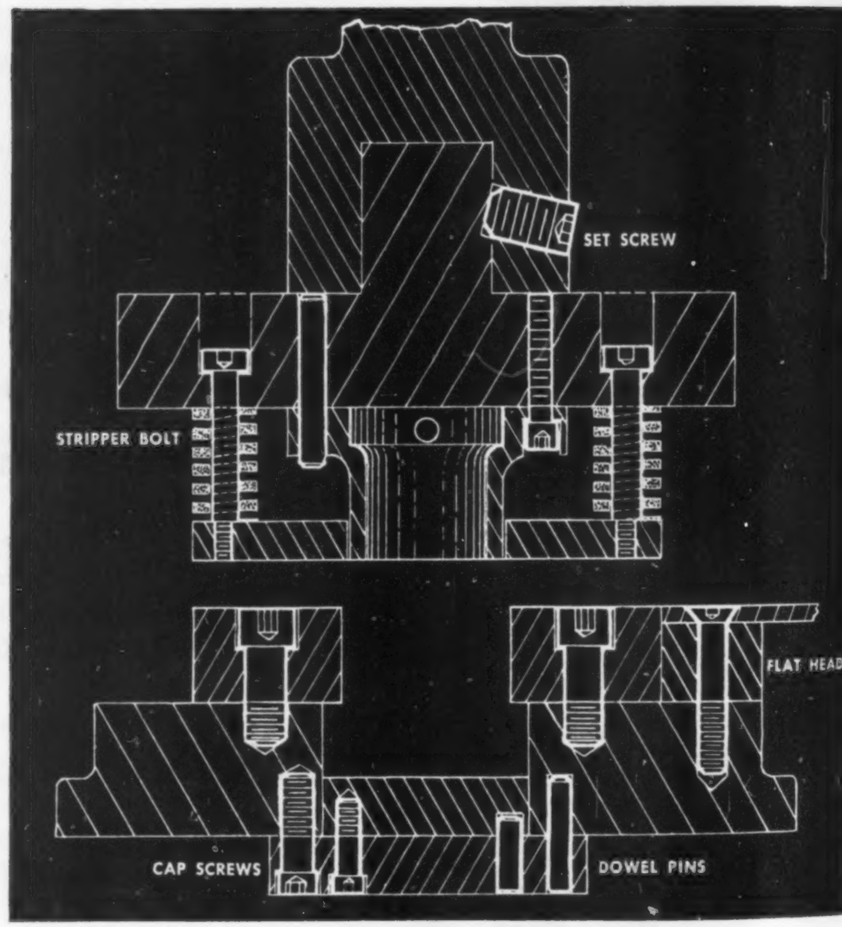


HK SOCKET SCREWS ARE:

- Made of special analysis alloy steel by a Holo-Krome patented process and heat treated to develop the utmost in physical properties.
- Quality controlled in Holo-Krome's own Physical and Chemical laboratories.

HK SOCKET SCREWS ARE:

- Held to Class 3 Thread Fit . . . Individually hand inspected.
- GUARANTEED TO GIVE UNFAILING PERFORMANCE.



Holo-Krome Field Engineers working with your H-K Authorized Industrial Distributor can help solve *your* fastening problems, too.

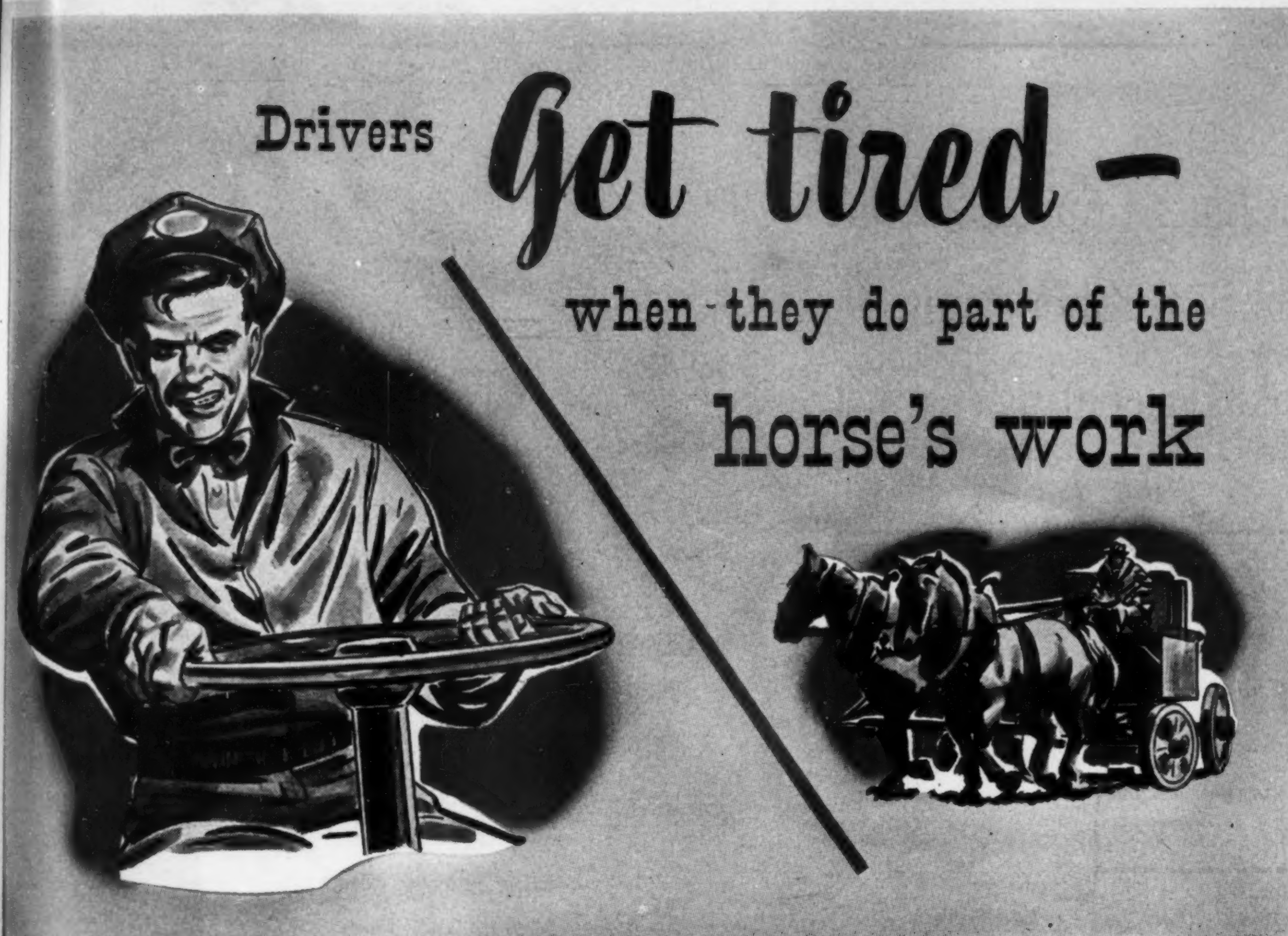
The Solution...

Specify *standard* Holo-Krome Socket Screw Products because internal wrenching permits maximum tightening – PLUS easy and rapid adjustment.

D3

HOLO-KROME
Completely Cold Forged
SOCKET SCREWS

THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN. U. S. A.



In the days when horsepower had four legs and was fueled with oats, drivers did not steer vehicles. They guided the team and the animals supplied the work of turning.

Today, with trucks, buses and materials handling equipment many times heavier than any horse-drawn vehicle, the driver too often has to supply the physical effort. The power to turn must come from his arms, shoulders and back.

He's doing part of the work that used to be done by horses. No wonder he tires and loses efficiency. It takes a lot of work to herd a vehicle that has heavy loading on the steering axle.

It's hardly progress to eliminate the horse and then do some of his work.

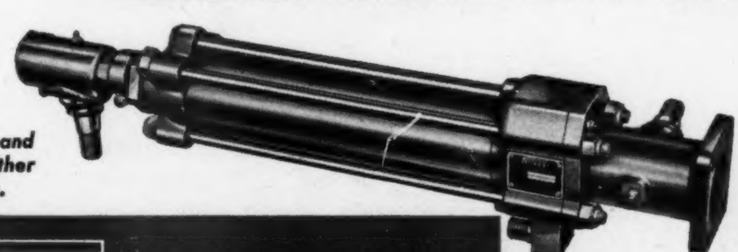
Vickers Hydraulic Power Steering doesn't give that work back to the horse—it gives it back to horsepower. It takes the work out of steering . . . requires no more effort than a "flick of the reins". Wheeling a vehicle around is much less tiresome, so, naturally the driver can do his job better and with greater safety.

VICKERS Incorporated

DIVISION OF THE SPERRY CORPORATION

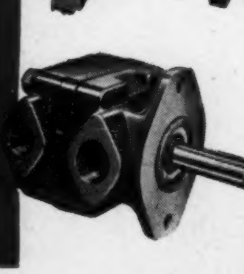
1430 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering Offices: ATLANTA • CHICAGO (Metropolitan) CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES (Metropolitan) NEW YORK (Metropolitan) • PHILADELPHIA • PITTSBURGH • ROCHESTER ROCKFORD • ST. LOUIS • SEATTLE • TULSA • WASHINGTON • WORCESTER



Ask for Bulletin 47-30a and data sheet #120397 for further information on these units.

VICKERS hydraulic
POWER STEERING
Is Effortless, Positive and Shockless



What's unusual about U. S. Rubber's new plastic coating?

For one thing, this new coating, called *U. S. Royalguard Protective Coating*, has very high film flexibility and adhesion. It protects:

Against attack by splash, drip, and spray from corrosive chemicals:

- **Chemical Processing Equipment**
- **Tanks**
- **Pipes**
- **Tank Cars**
- **Fittings**

Against weathering and rust:

- **Structural Steel Parts**
- **Machinery**

U.S. ROYALGUARD plastic coating being applied to yarn-carrying wheels used by textile industry. It is air-drying...no baking or other special treatment is required to produce a tough, flexible, highly corrosion-resistant film.

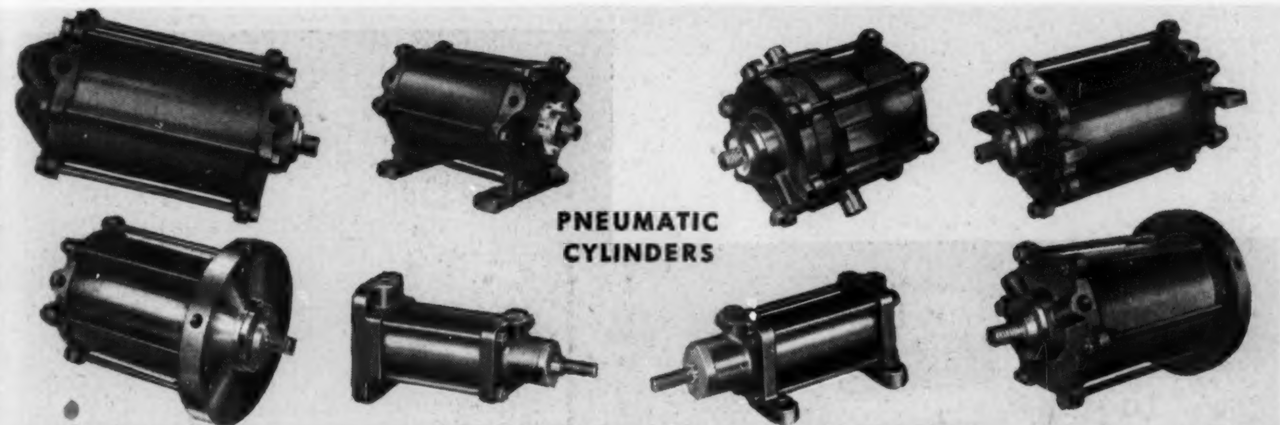
SAMPLE PLATE coated with Royalguard is bent in vice to demonstrate its high film flexibility and high adhesion. It can be used on steel, aluminum, concrete, hardwood or composition board.

Royalguard is a one-coat system...no primer is required. It will find its broadest use in chemical processing, rayon and cellophane production, photo finishing, pulp and paper manufacturing, sewage disposal, filtering, electroplating and in mining. Write to address below.

PRODUCT OF U.S. RUBBER SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION, ROCKEFELLER CENTER, NEW YORK 20, N. Y.



PNEUMATIC CYLINDERS

Q: Joe, do you think you can buy a cylinder to do this job? It looks plenty special to me!

A: Absolutely, Boss! Hannifin has more than 65 different mounting combinations in hydraulic cylinders, alone. And, if it has to be a special cylinder, Hannifin can build that, too.

Hannifin is *the* authoritative source for the broadest range of hydraulic and pneumatic cylinders—backed by an experienced corps of engineers, sold by a large force of factory-trained field engineers. Illustrated here are only a few of the many standard Hannifin hydraulic and air cylinders. Hannifin Corporation, 1115 South Kilbourn Avenue, Chicago 24, Illinois.

Complete hydraulic cylinder catalog, illustrating design features, styles, dimensions. Also bore tables, engineering data and formulae.

Complete illustrated pneumatic cylinder catalog giving design and construction features, bore tables, mounting styles and other information.

HYDRAULIC CYLINDERS

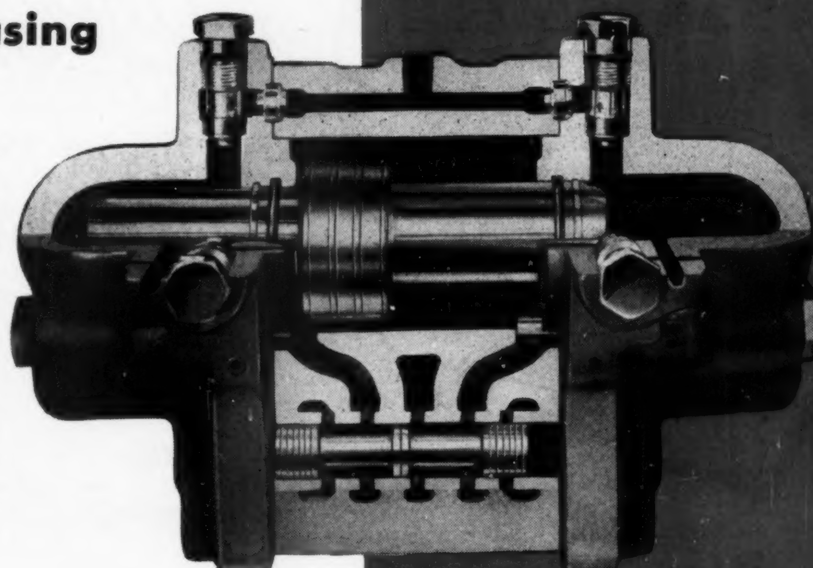
YOU CAN BE *SURE*, IF YOU—do <u>ALL</u> you CAN do . . . with

HANNIFIN

Air and Hydraulic Cylinders • Hydraulic Power Units • Pneumatic and Hydraulic Presses • Hydraulic Riveters • Air Control Valves

Multiply Pressure

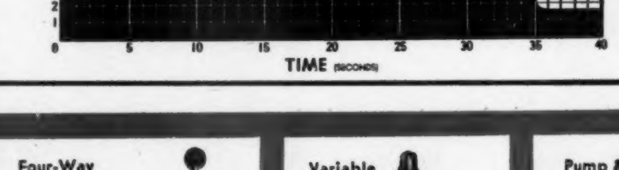
without increasing horsepower



On most presses and in many other applications, pressure requirements change during the operating cycle. The Racine "Variable Volume" low pressure pump with a Racine Pressure Booster can be used to develop and hold up to 5000 psi. The horsepower input does not exceed the power needed to operate the pump at its low pressure setting.

This means lower first cost, less horsepower consumption, reduced cylinder sizes — a more compact over-all design. Pressure and volume delivered can be controlled by one of the built-in governors that are standard for all RACINE pumps.

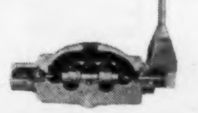
OPERATING ECONOMIES—*The red area in the graph below shows the horsepower lost during one holding cycle of a simple press circuit using a constant volume pump. The black area shows the horsepower consumed when a Racine "Variable Volume" Pump and Pressure Booster is used to do the same work.*



Write for new 3-color Catalog P-10-D covering RACINE'S complete line of "Variable Volume" Pumps, Valves and Pressure Boosters.

OTHER RACINE HYDRAULIC PRODUCTS

Four-Way Valves

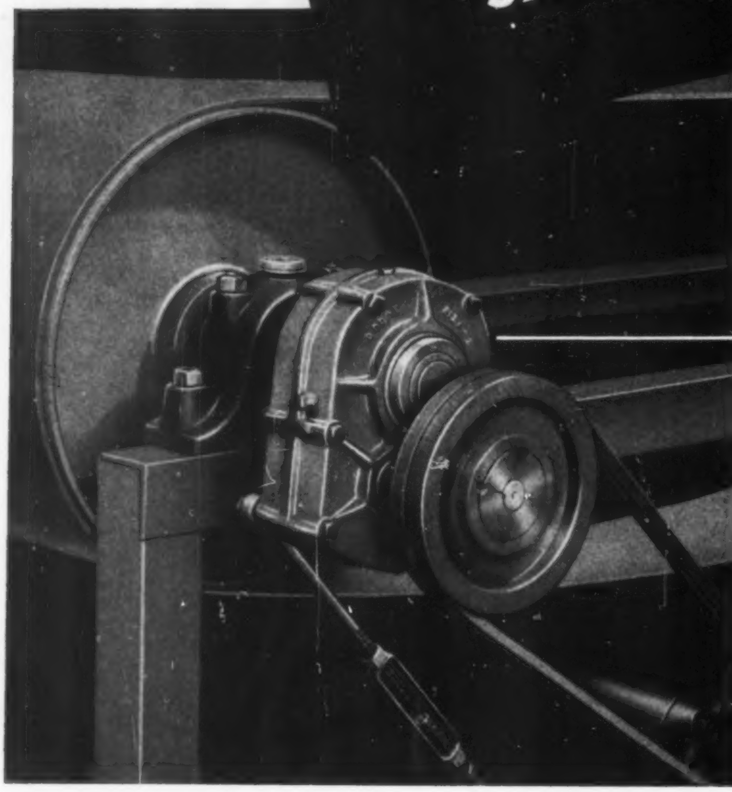


Variable Volume Pumps

Pump & Reservoir Units

RACINE TOOL AND MACHINE COMPANY
1773 State Street, RACINE, WISCONSIN, U. S. A.

THE SPEED REDUCER THAT SAVES YOU MONEY!



Dodge

Torque-Arm

America's Most Complete Line of Shaft-Mounted Speed Reducers

- No special engineering required. No foundation to provide. No flexible couplings. No sliding base. No "lining-up" difficulties. No expensive installation. Stock TAPER-LOCK sheaves prescribed for each job to provide desired speeds. Application to other machines is practical and easy.
- Unit is driven through any V-Belt Drive. Torque-arm, fastened to any fixed object, anchors the reducer unit. Turnbuckle provides fast and accurate adjustment of belt tension.
- Backstop available from stock when required. Simple. Positive. Easily installed. Sealed inside the reducer housing.
- Compact, light weight, *rugged.* Quality built by Dodge for Dodge *dependable* service.
- Built in two series—Single and Double Reduction. Capacities from 1 to 27 h. p. Speeds from 12 to 330 rpm. Available from distributors' stocks.
- WRITE for special bulletin A602.

DODGE MANUFACTURING CORPORATION, 3300 Union Street, Mishawaka, Indiana

DODGE

of Mishawaka, Ind.

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new cost-saving methods. Look for his name under "Power Transmission Equipment" in classified phone book.

FIRST IN POWER TRANSMISSION MACHINERY!

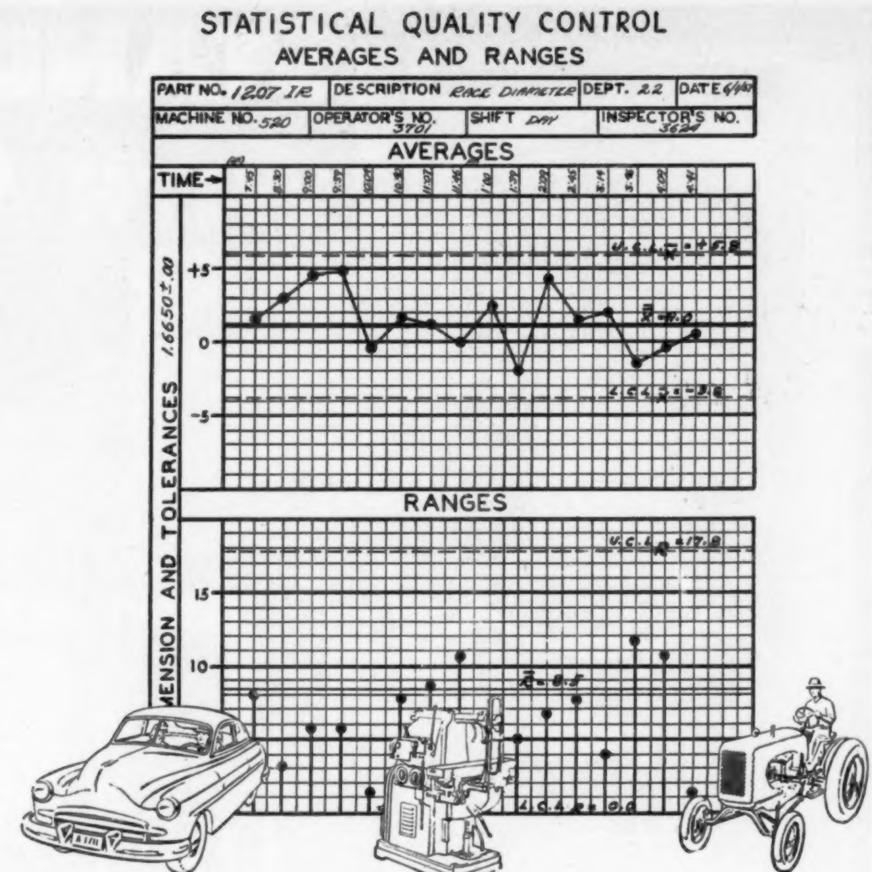
V-BELTS AND TAPER-LOCK SHEAVES

DODGE-TIMKEN PILLOW BLOCKS

ROLLING GRIP AND DIAMOND D CLUTCHES

SOLID STEEL CONVEYOR PULLEYS

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY, CHICAGO THRIFT-ETCHING CORPORATION, 1555 SHEFFIELD AVENUE, CHICAGO, ILLINOIS



Beating Friction... with Statistical Quality Control

Control of quality *has* to be the code of production in making of ball bearings to meet precise performance standards. Federal—a consistent supplier to the automotive industry for thirty-five years—makes statistical quality control an integral part of its production. The result: ball bearings that are helping automotive engineers, machine-tool builders, agricultural equipment designers, textile manufacturers develop high-performance products.

Close-tolerance manufacture demands close control of production, and a constant awareness of new techniques. For example, Federal's comprehensive statistical quality-control program maintains rigid watchdog inspection on every ball bearing, gears production to the exacting demands of bearing engineers. That's why Federal—the *experienced* ball bearing-maker—can help you eliminate friction, improve product performance.

Every Federal ball bearing is a product of the combined skills of IMAGINATIVE RESEARCH · ADVANCED ENGINEERING · ALERT MANUFACTURING · RIGID QUALITY CONTROL · SUPER-PRECISE TESTING.

THE FEDERAL BEARINGS CO., INC.
POUGHKEEPSIE, NEW YORK

Makers of Fine Ball Bearings

Federal BALL BEARINGS

ONE OF AMERICA'S LEADING BALL BEARING MANUFACTURERS

Quality
Since 1908

STANDARDIZE WITH OHIO

Illustrated above shows how an Ohio HSO Speed Reducer operates a single end drive on a Multi-Duty Automatic Air Filter manufactured by the American Air Filter Co., Inc.

Photo at right shows a 2 section unit and position of single end drive.

There are many manufacturers whose names are not familiar to the consumer public, but whose companies are indirectly contributing to their acceptance of the nation's greatest products.

Such is the case of Ohio Gear in supplying Speed Reducers to the American Air Filter Co., Inc., of Louisville, Ky., the world's largest manufacturer of air cleaning and dust control equipment. American Air Filter ship their products thousands of miles from the factory, including foreign ports in Mexico, South America, Europe, South Africa, India and Australia.

It takes a lot of faith and confidence in a Speed Reducer to keep your product and good name operating at such great distances.

Thousands of manufacturers depend on American Air Filter products to produce clean sanitary air in the production of Foods and Beverages, Film Processing, Electronics, Textiles, Plastics and Synthetics, Pharmaceutical and Chemicals. The American Air Filter Co., Inc., has a great responsibility in protecting you personally and the great names which are symbols of quality and value.

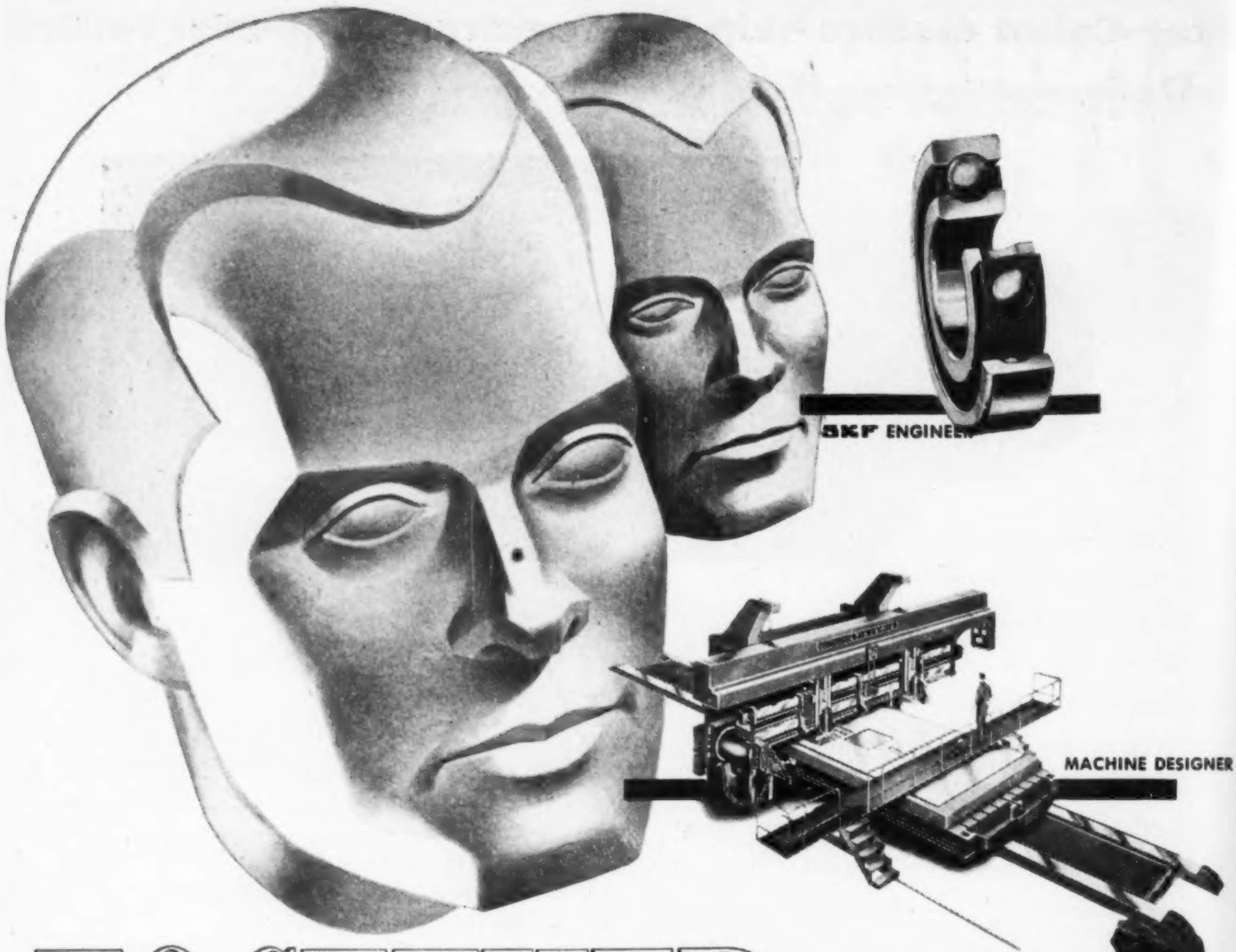
Protect YOUR product and operation with Ohio Speed Reducers and Ohio Gears.

ESTABLISHED 1915

THE OHIO GEAR COMPANY

1338 EAST 179th STREET • CLEVELAND 10, OHIO

OHIO GEARS



TOGETHER

a team that "cuts" production time

The world's first machine tool for the three-dimensional routing of self-reinforced aircraft skins will soon be in operation. Heart of its accuracy are Onsrud Cutterhead Motors—their accuracy assured by SKF Single Row Deep Groove Precision Ball Bearings.

Why, when today it's pretty hard *not* to buy good bearings, did Onsrud specify SKF for this Giddings & Lewis "Skin Mill"?

Simply because by specifying SKF, over the years Onsrud has gotten other things along with the bearings—the teamwork of experienced bearing engineering specialists at SKF's headquarters; the teamwork of SKF field men who are qualified specialists in the application of bearings to machine tool designs; the expanding production facilities of efficient, up-to-date plants.

Whatever your product, *your* engineers and designers can have this helpful teamwork simply by asking for it.

7169

SKF
BALL AND ROLLER BEARINGS

8 REASONS WHY SKF IS PREFERRED BY ALL INDUSTRY

integrity • craftsmanship • metallurgy
tolerance control • surface finish • product uniformity
engineering service • field service

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.—*manufacturers of* **SKF** *and* HESS-BRIGHT *bearings.*

STANDARD IN PRINCIPAL FEATURES BUT ADAPTABLE IN CRITICAL DETAIL

Farrel speed reducers have been developed for continuous, trouble-free operation under difficult service conditions. Gears, shafts and bearings are factored to safeguard against interruption of vital processes; gear cases are proportioned to withstand repeated heavy peak loads; joints are sealed to prevent entrance of dust and dirt.

But, that is not all. Without sacrificing the advantages of general standards, the design of these units permits an engineering freedom in proportioning gears, shafts, bearings and even some housing dimensions to meet specific load, speed and service requirements. This flexibility allows an engineering exactness in critical detail, which has resulted in the solution of innumerable application problems.

Write for further details. Ask for a copy of Bulletin 449—no cost or obligation.

FARREL-BIRMINGHAM COMPANY, INC. • ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo, N. Y. *Sales Offices:* Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Cleveland, Cincinnati, Detroit, Chicago, Los Angeles, Tulsa, Houston, New Orleans.

FB-592-A

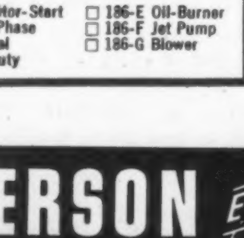
PRECISION GEARS

The quiet, vibration-free performance you can expect from the herringbone gears used in Farrel speed reducers results from extreme accuracy of tooth spacing, contour and helix angle . . . qualities inherent in the Farrel-Sykes method of gear generation. Precision manufacture and highest grade materials contribute to long gear life.

Farrel-Birmingham®

Two are Better Than One

. . . to prove this point



Write for these Emerson-Electric Motor Data Bulletins

Appliance and equipment manufacturers, with applications for motors of 1/20 to 5 h.p., can profitably use these reference guides. Specifications, construction and performance data are included for these motors:

- ☐ 186-A Capacitor-Start
- ☐ 186-B Split-Phase
- ☐ 186-C Integral
- ☐ 186-D Fan-Duty
- ☐ 186-E Oil-Burner
- ☐ 186-F Jet Pump
- ☐ 186-G Blower

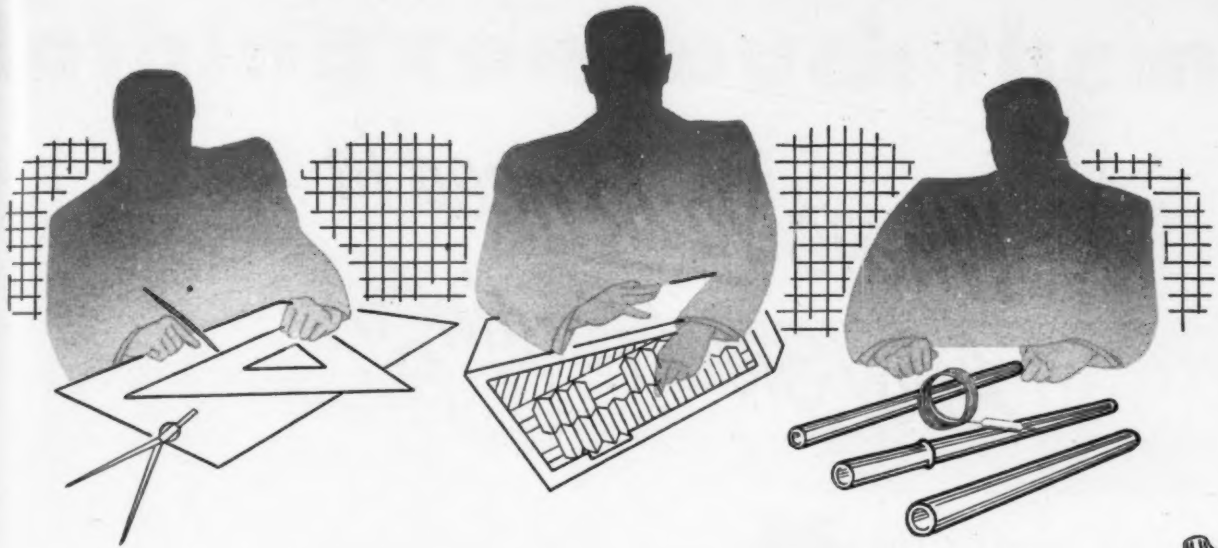
There's nothing unusual in being able to produce *one good motor*. But when that single unit must be multiplied by thousands, and all must match the original, it is a factor you should consider in selecting the motor for your products.

In Emerson-Electric motors, uniformity in appearance is unquestioned. *Uniformity of performance,* the important factor, has earned for them wide acceptance among America's leading appliance and equipment manufacturers. Knowing the reputation of their products is determined by uniformly dependable performance, these manufacturers turned to Emerson-Electric motors.

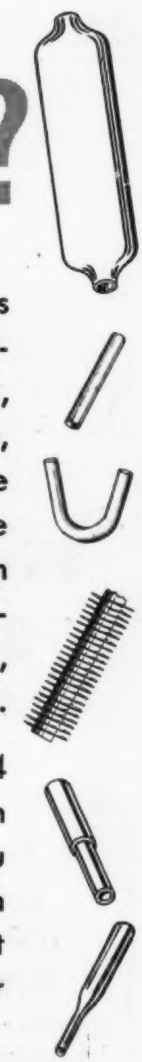
More than 61 years of precision motor production has made uniformity one of the many advantages inherent in Emerson-Electric motors. For full information on this complete line of motors in the 1/20 to 5 h.p. range, write today to:

THE EMERSON ELECTRIC MFG. CO.
St. Louis 21, Mo.

EMERSON ELECTRIC
MOTORS • FANS APPLIANCES



DESIGNING New Products? IMPROVING an Existing One? TUBULAR Parts Used?

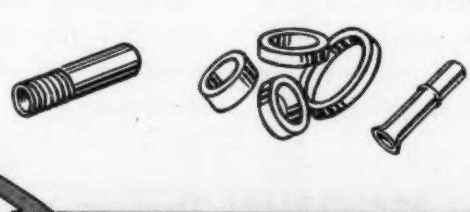


Our Customers Engineering Service can lend a helping hand and provide as much assistance as you want: help develop the design; suggest suitable materials; provide the necessary plain tubing or fabricate it into a special form; carry the development on through pilot tests or help produce the finished product.

Since we are accustomed to working with various government agencies, you can be assured that any developments carried on with you will likewise be kept on confidential basis.

Our tube fabrication facilities embrace such operations as bending, spinning, swaging, piercing, threading, counterboring, tapping, and beading. Seeing that the product reaches you in a usable condition is also of deep concern to us. We provide the most practical type of packing—crating, boxing, packaging, palletizing, etc.

With a background of over 34 years' specialized experience in tube manufacturing, we offer you help that should prove valuable in the production of any tubular part you contemplate. We invite your inquiries.



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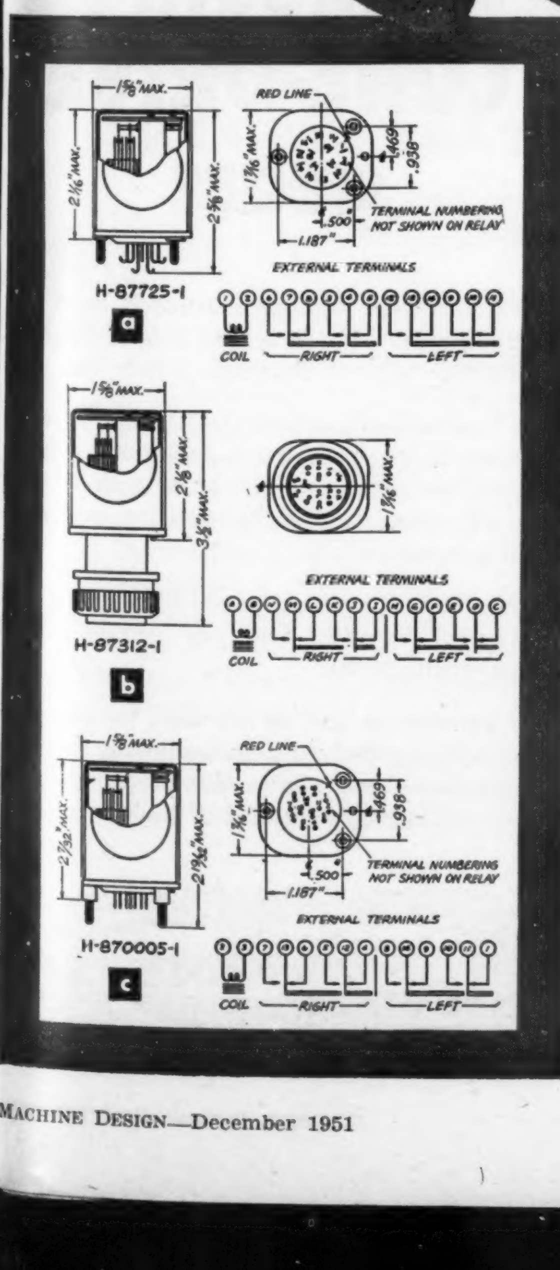
Nothing can touch them!

these tiny Class "S" Relays from

Automatic Electric

are HERMETICALLY SEALED



To give your product high performance standards, use relays that meet *aviation's* highest standards. These Automatic Electric Class "S" Relays meet them all!

small, light-weight—mount in any position in a restricted space...save valuable room, hold down weight.

resist shock and vibration—contact operation is dependable at vibration up to 10.5 G's.

protected from harmful conditions—operate in "ideal" atmosphere of dry nitrogen, sealed against dust, corrosion, atmospheric pressure changes and tampering.

versatile in application—as shown at left, Class "S" Relays are available with solder-or socket-type terminals...and with the contact arrangements *you* specify.

Other telephone-type relays can also be supplied, with or without hermetically sealed enclosures. Write for circulars. Address: AUTOMATIC ELECTRIC SALES CORPORATION, 1033 West Van Buren St., Chicago 7, Ill. In Canada: Automatic Electric (Canada) Ltd., Toronto. *Offices in principal cities.*

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Seals safeguard pressure lube system in air compressor crankshaft

Gardner-Denver Model WB Air Compressors employ a simple and practical pressure system to lubricate the crankshaft bearings. Oil seals are used to safeguard bearings and insure efficient operation of the pressure system.

In these compressors, lubricating oil is introduced under pressures ranging from 20 to 45 pounds. Operating temperatures reach 130°F, and shaft speeds of 870 rpm are maintained continuously.

The lubricant is introduced at the forward main bearing (Figure 1). It passes from the end plate through a brass oil-introducing ring, and on to a rifle-drilled crankshaft. The oil-introducing ring is kept from turning by a snap ring, and is hydraulically balanced in position by oil around the crankshaft.

National Oil Seals installed in the end plate prevent leakage or loss of lubricant, help maintain lube pressure and the balance of the oil-introducing ring.

Oil seals used in this application are National 50,000 series spring-loaded units (Figure 3). Sealing members are of Nationalized leather, impregnated to retain shape and resist wear. Here, as elsewhere in Gardner-Denver units, standard design seals are used. In many cases, standard designs can solve sealing problems quickly and economically. In other cases, special designs are necessary. Whatever the need, National Oil Seal Engineers bring 25 years of sealing experience to your problem. Write or call the nearest National office for prompt assistance.

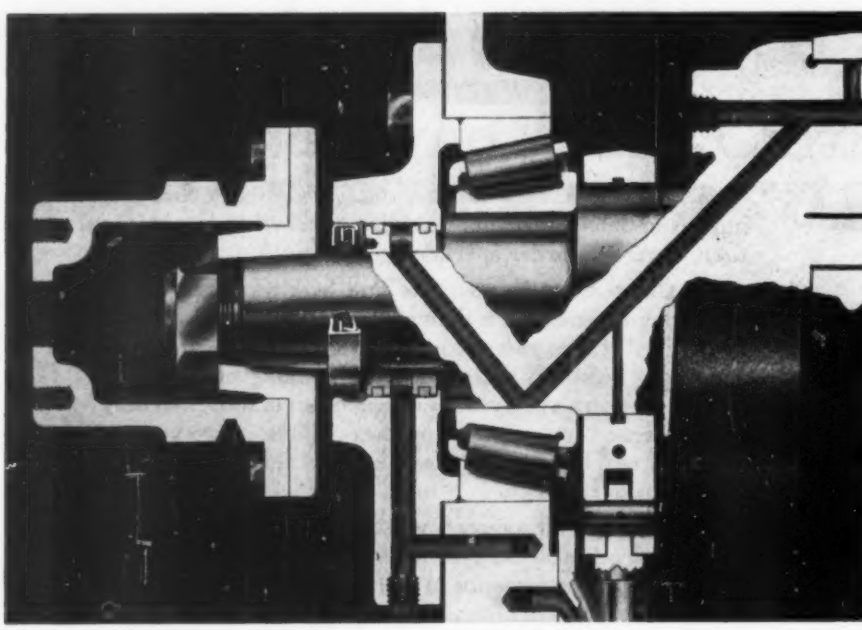

Fig. 1 Oil introducing assembly

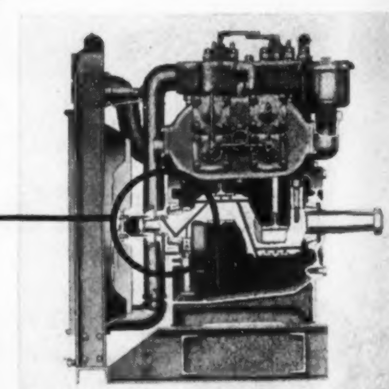

Fig. 2
Gardner-Denver Model WB Air Compressor

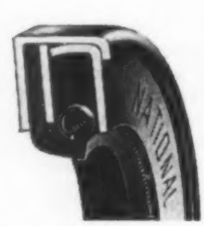

Fig. 3 National 50,000 series oil seal

"Let Your Decision be Based on Precision"

NATIONAL
OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, California
Plants: Redwood City, Calif.; Downey (Los Angeles County), Calif.; Van Wert, Ohio

2282

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DALLAS, TEXAS . . . *30½ Highland Park Village, Justin 8-8453*
DETROIT, MICH. . . . . . *726 Lothrop Avenue, Trinity 1-6363*
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MILWAUKEE, WIS. . . *647 West Virginia Street, Broadway 1-3234*
NEW YORK CITY, N. Y. . . *122 East 42nd Street, Lexington 2-8260*
PHILADELPHIA, PA. . . *401 North Broad Street, Bell-Walnut 2-6997*
REDWOOD CITY, CALIF. . . *Broadway and National, Emerson 6-3861*
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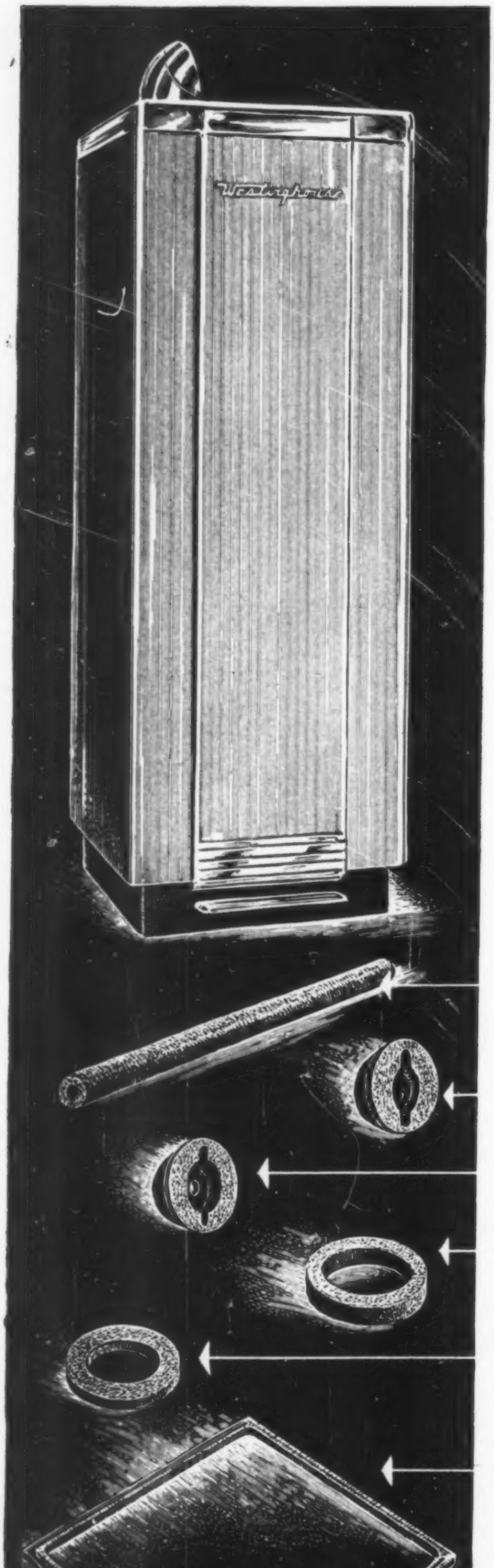

This water cooler
has a Longer, Better Life . . . works less each day

with SPONGEX®

CELLULAR RUBBER

Corrosion...deterioration...mechanical failure...repairs and parts replacement—an inevitable sequence wherever moisture condensation collects. It's a problem particularly troublesome in refrigerating equipment—but not in this Westinghouse water cooler!

Westinghouse has given its cooler a wardrobe of Spongex cellular rubber. Exposed cold surfaces—tubing, valves, even the waste water drain—are covered by custom molded Spongex parts. These Spongex parts not only prevent condensation but their insulating qualities increase refrigerating efficiency. For this cooler, Spongex means a longer, better, more efficient life.

The Westinghouse Wardrobe of SPONGEX

Tube insulator—
covers cold water tubing that supplies the drinking bubbler.

Regulator valve cap—
covers the cold surfaces of valve. Elasticity and flexibility of cap makes it easily removed for valve adjustment.

Water valve cap—
covers shut off valve controlling water flow to bubbler.

Basin drain insulator—
covers exposed end of the waste water drain.

Basin drain seal—
forms a water tight seal between bottom of the water cooler basin and top of the drain. The compressibility of Spongex compensates for variations in the clearance between basin and drain.

Door gasket—
forms an air tight seal for the door opening into the cold storage compartment. The gasket also seals off the insulating air space between the inner and outer panels of the door.

Perhaps Spongex can help better your product, too. We would be happy to hear from you.

The World's Largest Specialists in Cellular Rubber

THE SPONGE RUBBER PRODUCTS COMPANY
400 Derby Place, Shelton, Connecticut

Dentists Can Tell You Why Stainless Tubing for These

Dental molding flasks and saliva ejector stand up under constant use, because they are made from Carpenter Stainless Tubing. The flasks withstand temperatures up to 1700° F., while the ejector is frequently sterilized.

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Reports from dozens of experienced fabricators tell us that there are two reasons why it's easy to work with this tubing. First, analysis-tolerance-finish (and specials such as hardness) are always just the way you want them. That eliminates a lot of problems at the start of any job. Second, they tell us that the personal help they can get on any Stainless Tubing job helps to keep unit costs as low as possible.

When you want to discuss your design or fabricating problems, call your nearest Carpenter Stainless Tubing Distributor. He will be glad to put his experience to work on your essential jobs, and to help you plan for the future, too.

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Alloy Tube Division, Union, N. J.

Export Dept., Reading, Pa., "CARSTEELCO"

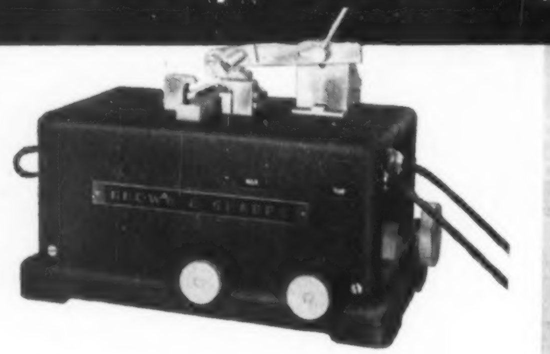
Carpenter

STAINLESS TUBING

more than corrosion resistance

—guaranteed on every shipment

Faster, Closer QUALITY CONTROL



Special gaging fixture made by Brown & Sharpe for inspecting dimensions, side parallelism, and side squareness of cutter blades. Employs 4 Gage Head Cartridges . . . used with 4 Amplifiers.

Brown & Sharpe Electronic Amplifiers with built-to-order Gaging Fixtures

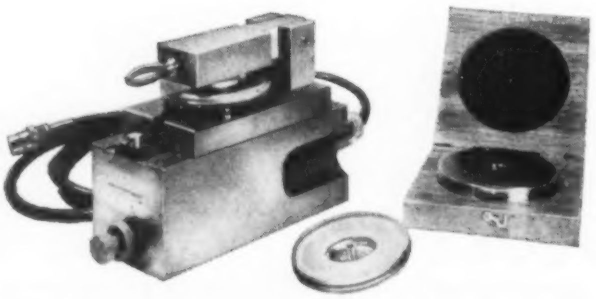
Here's an unbeatable set-up for fast, low-cost precision inspection or gaging of many small parts that usually demand high-skilled measurements. Special gaging fixtures, custom-built by Brown & Sharpe, can reduce exacting measurements to a simple, speedy routine.

Employing versatile Brown & Sharpe Gage Head Cartridges, these low-cost fixtures in combination with Brown & Sharpe Electronic Amplifiers provide flexibility that enables gaging to be done right at the machine or production line. Work is easily checked by .0001" to .00001", and measurements are visually magnified from 1800 to 18,000 times by the Amplifier . . . permitting operators to read "tenths", or finer, as easily as inches.

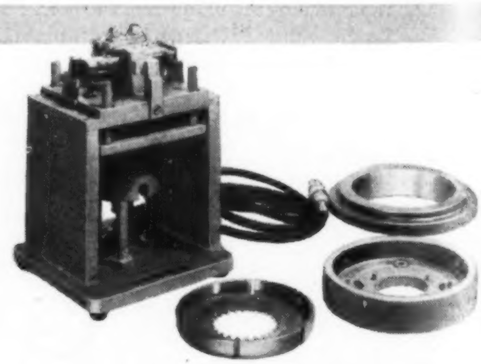
Investigate Brown & Sharpe Electronic Gaging Equipment for improving *your* quality control. It can be applied for gaging thickness, length, angle, parallelism, diameter, taper or combinations of several dimensions. For details write Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.

WE URGE BUYING THROUGH THE DISTRIBUTOR

Electronic Amplifier No. 950.



Special gaging fixture, custom-made by Brown & Sharpe, permits gaging of meter valve plate flatness to .00001", when used with Brown & Sharpe Amplifier.



Custom-made fixture, employing Brown & Sharpe Gage Head Cartridge and one Amplifier, simultaneously measures major and minor I.D.'s of tapered bores and indicates accuracy of internal angle.

Brown & Sharpe BS

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MORE than 90% of all Peerless Motors are custom manufactured to meet the specific operating requirements of the equipment with which they are to be used.

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Manufacturers of Quality Motors Since 1893

Single Phase • Polyphase • Direct Current • 1/4 to 15 H.P.

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...with TUTHILL Stripped Pumps

This typical installation shows how Tuthill Stripped Pumps can help you save space, material and money by incorporating the pump directly into the design of your equipment. Ideal in lubrication, coolant, and hydraulic service. Write for Tuthill Stripped Pump bulletin.

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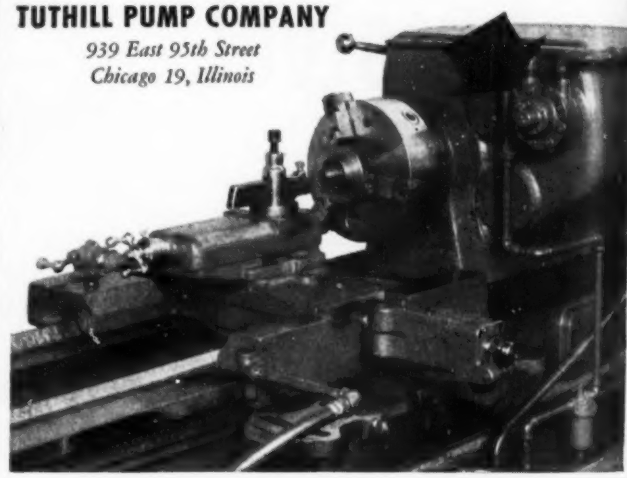

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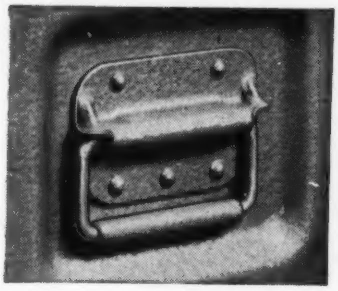

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Here is the handle you have been looking for—one that is ideally suited for anything that must be lifted by a side carrying handle. Bendix-Friez engineers developed this handle to meet Air Force and other Government specifications for many kinds of special equipment. The unique, rugged design of this handle, with its "snap-back" feature, is such that neither shock nor vibration will cause it to rattle. Built of aluminum and stainless steel, it can be riveted or welded to the side surfaces of any kind of container or depressed in the sides. Available in large or small lots, orders will be filled promptly. *Write today for our new lower prices.*

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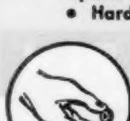
Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Miscellaneous Precision Parts.



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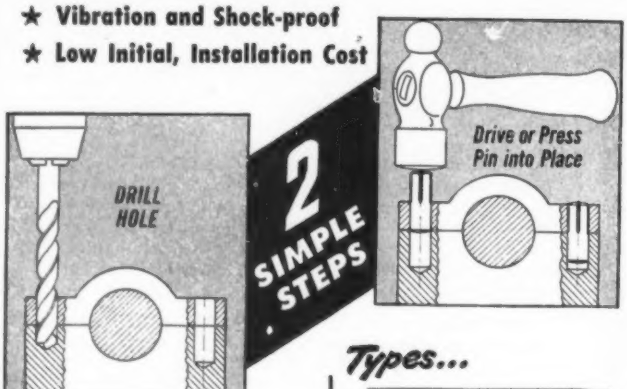
Simple... Dependable...

low-cost fastening with

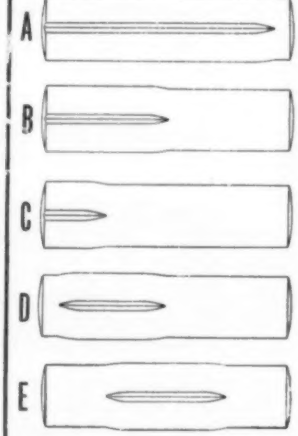
DRIV-LOK PINS

TYPE "C" PIN

- ★ Simple Installation
- ★ Versatile...Types for Most Applications
- ★ Wide Selection of Materials
- ★ Vibration and Shock-proof
- ★ Low Initial, Installation Cost

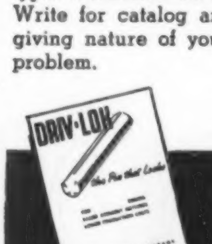


Types...

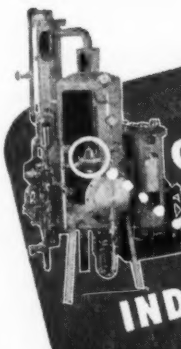


DRIV-LOK Pins are widely used as hinge and pivot pins because they permit maximum free rotation of one part, while remaining securely locked in the other. Quick, easy installation of DRIV-LOK Pins cuts assembly costs, waste motion is reduced and product improvement results.

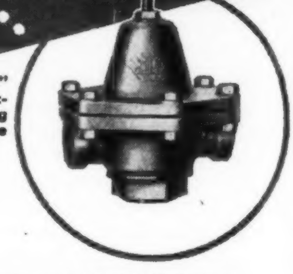
DRIV-LOK Pins are made in many types to handle most applications. Write for catalog and samples, giving nature of your fastening problem.



DRIV-LOK PIN COMPANY
715 Chauncey St. • Sycamore, Ill.



CASH-ACME VALVES DEMANDED BY INDUSTRY *Everywhere*



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There's a CASH-ACME Automatic Valve to handle anything that flows—Water, Air, Steam, Gases, Chemicals, Re..igerants, Oil, Gasoline and all other types of liquids.

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BARCOL *synchronous* MOTORS

Type KYAZ BARCOL MOTOR

An open type, powerful, geared BARCOL MOTOR drives the drum in this multi-speed Gorrell & Gorrell Mono-drum. This motor is completely submerged in oil to give years of trouble-free service. The following features are incorporated in the Barber-Colman line of Synchronous Motors:

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- Open or enclosed
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- 25-60 cycles

Our engineering staff is ready to help you with your motor problem. Write today, outlining the application in which you are interested.

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OTHER BARCOL MOTORS — Unidirectional • Reversible • With and without reduction gearing • Open and enclosed.

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ROCKFORD, ILLINOIS, U. S. A.

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AVAILABLE OR WANTED

WANTED: Mechanical Design Supervisor. We have a rare opportunity for an ingenious mechanical designer to step into a position which will challenge his whole creative ability. He will be delegated responsibility for product design. He will coordinate the efforts of retained designers until the time he has selected and trained a staff of competent subordinates, and then the mechanical design function will be under his direction. He and his group will design new mechanical products and redesign the old. This man must be a graduate engineer and have a proven history of original mechanical designs particularly in mechanisms. Five to ten years experience doing design and development work on products such as automatic machinery, packaging machinery or as a consultant in a design company would be appropriate. We are a 106-year-old company and are the established leader in bowling and billiards. Ours is a multi-plant operation with young, progressive management. This opening is in our main plant in Muskegon, Michigan, a modern city of 100,000 where you will find good housing and friendly, neighborly living on the shores of Lake Michigan. Address replies to J. W. Edmunds, The Brunswick-Balke-Collender Company, 623 S. Wabash Avenue, Chicago 5, Illinois.

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WANTED: Research engineer interested in design and testing of special mechanisms; electronic instrument specialists, interested in developing new applications of existing oscilloscopic and oscillographic instruments; technical writers, photo retouchers; if interested in joining a small (200 men) growing organization, should contact Mr. Charles E. Balleisen, Supervisor, Mechanical Laboratory, Southwest Research Institute, 8500 Culebra Road, San Antonio, Texas.

AVAILABLE: Machine designer with 15 years experience in designing, tool engineering and estimating for appliances and electrical machinery. Willing to relocate. Married with family. Please write for complete resume. Address Box 755, MACHINE DESIGN, Penton Bldg., Cleveland, Ohio.

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WANTED: The Taylor-Winfield Corporation, 1052 Mahoning Avenue, N. W., Warren, Ohio, a leading electric resistance welder and electronic control manufacturer, has five openings for Design Engineers in their Mechanical Engineering Department. These are permanent positions, provided men selected prove they have the necessary skill and ability. Men with resistance welding design experience are preferred. However, recent mechanical engineering graduates will be given careful consideration. The work is 100% board work, involving the design of electric resistance welder machines and component parts such as jigs and fixtures used in conjunction with this type equipment. Experience or training in electro-mechanical machinery would be a definite asset in meeting the job requirements. Interested applicants should write the Personnel Department, stating age, education, experience, salary expected and other pertinent data.

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WANTED: Axelson Manufacturing Company, oldest and largest machine tool builder in the West, has openings for qualified machine tool design engineers. If you are qualified and desire to make a permanent connection with an assured future in Southern California, write full details of your background to Axelson Manufacturing Company, Engineering Department, Box 5335, Vernon Station, Los Angeles 58, California.

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WANTED: Mechanical Engineer. National Paper Converter desires Mechanical Engineer with machinery design experience. Must be willing to do board work. Excellent opportunity. Must locate in Dallas, Texas. Address Box 754, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

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WANTED: Layout men to design precision turning machines. Opportunities in expanding organization. The Monarch Machine Tool Company, Sidney, Ohio.

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WANTED: Product Design Engineers to do creative development work. Varied individual projects afford opportunity for originality, initiative, and responsibility. Engineering degree and design experience required. Write details of your background. Mast Development Company, Inc. 2212 East 12th Street, Davenport, Iowa.

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WANTED: Design & development engineers. Several graduate mechanical engineers with one to ten years experience in development of small mechanical devices, valves or valve spcialties, wanted by the Chicago Factory of Minneapolis-Honeywell Regulator Company. Position offers opportunity for extensive use of technical knowledge and ingenuity on development of a variety of mechanical control devices. These are good permanent positions with opportunities for advancement, and with salary proportionate to ability. Minneapolis-Honeywell Regulator Co., 2301 N. Knox Ave., Chicago, Illinois. Attention: W. W. Voss.

ADVERTISING INDEX

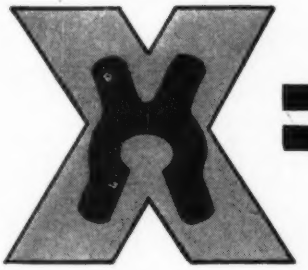
ADVERTISING INDEX

Found... A SIMPLE FORMULA FOR BIGGER PROFITS—

X=PRODUCTION TIME *Savings*

X=PRODUCTION COST *Savings*

X=PRODUCTION FAILURE *Savings*



= *Standard* X-WASHERS

This revolutionary fastener in many cases provides greater thrust strength, yet it is more easily, more quickly applied than inefficient old-type fasteners.

With only a pair of pliers the STANDARD X-WASHER is clinched to a perfect 360° closure . . . easily removed with the same simple plier operation.

Cut your production time and production costs to the minimum . . . cut production failures . . . demand STANDARD X-WASHERS —the "proven" figure in the formula for BIGGER PROFITS!

—1001 APPLICATIONS—

Warner Automotive Parts Division—Borg-Warner Corporation says "The efficient installation of the STANDARD X-WASHER on our truck power take-off units makes for an improved product. Since the X-WASHERS are easily removed, disassembly for repairs and service can be done in a minimum amount of time."

The American Machine & Foundry Company, Buffalo, N. Y., says, "In the manufacture of our AMF Automatic Pinspotter, an automatic device for setting bowling pins and returning the bowled ball, the X-WASHERS play an important role. Our assembly superintendent has found that the ease of installation makes it a very good production item. This feeling is shared by our Engineering Department as shown by the number of uses made of the X-WASHER."

Range of X-WASHER sizes immediately available for pin diameters from 3/16 to 9/16 inches in diameter. STANDARD grooved pins are made available for all sizes of STANDARD X-WASHERS or to your specifications. Send your print for a prompt quotation.

Write for Standard's Detailed Catalogue, today!

STANDARD Locknut and Lockwasher, Inc.

510 NORTH CAPITOL AVE. • INDIANAPOLIS 4, INDIANA

How to help a spindle carrier deliver precision

WITH six work spindles in its spindle carrier, the Greenlee automatic screw machine, shown below, can perform six cutting operations simultaneously. To maintain precision in each operation, all work spindles are mounted on Timken® tapered roller bearings.

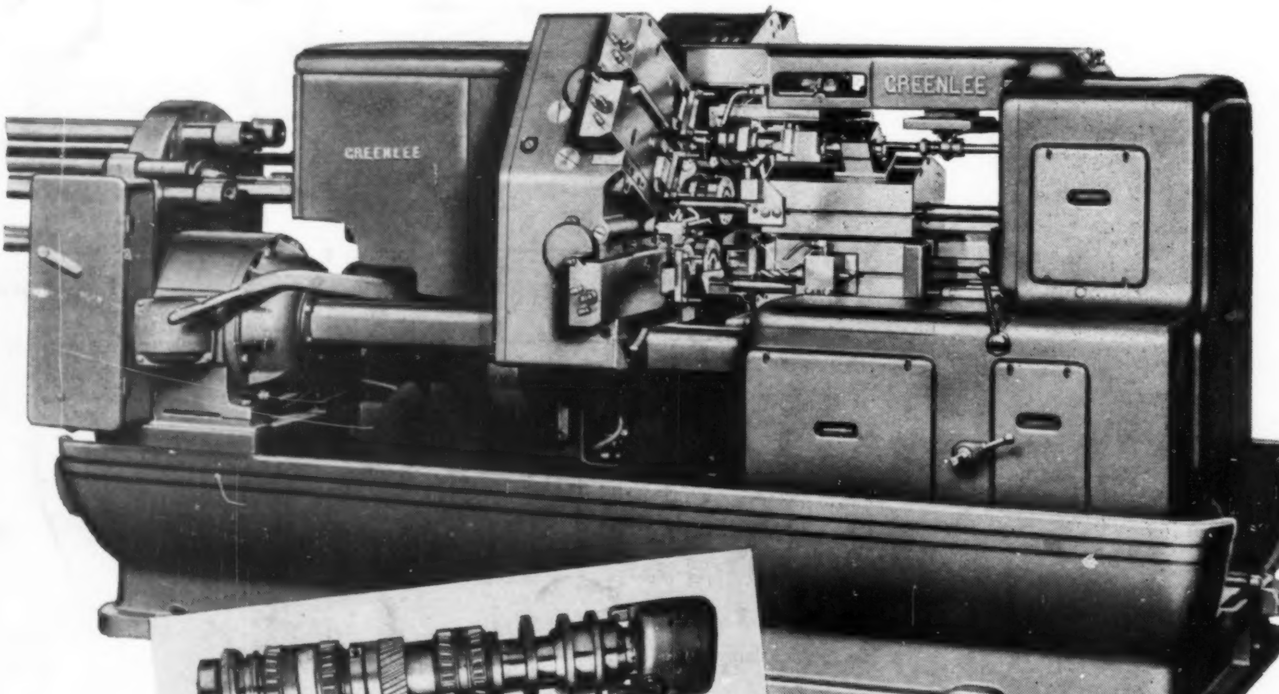
Timken bearings help eliminate spindle chatter. Work turns smoothly and accurately. Set-ups stay set. Greenlee Bros. & Co. also use Timken bearings in the gear box to provide a smooth flow of power through a wide range of speeds and feeds.

Because of tapered construction, Timken bearings take both radial and thrust loads in any combination, hold spindles in proper alignment. Line contact between rollers and races provides extra load-carrying capacity. The true rolling motion and incredibly smooth surface finish of Timken bearings practically eliminate friction.

Since Timken bearings are engineered for the job, precision manufactured and made of special analysis Timken fine alloy steels, they normally last the life of the machine.

No other bearing can give you all the advantages you get with Timken tapered roller bearings. Make sure you have them in every machine tool you build or buy. Look for the trademark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



How the **GREENLEE BROS. & CO.** mounts the spindles of its automatic screw machines on Timken bearings to insure lasting precision.

FINISHED TO CLOSER TOLERANCES

Finishing to incredible smoothness accounts for much of the precise, smooth rolling performance of Timken bearings. This honing operation is typical of the amazingly accurate manufacturing methods at the Timken Company.

The Timken Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ◯ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL AND THRUST → ← LOADS OR ANY COMBINATION